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THE

FIRST LINES OF BOTANY,

OR

PRIMER

TO THE LINNÆAN SYSTEM;

BEING

A SIMPLIFIED INTRODUCTION

TO A

KNOWLEDGE OF THE VEGETABLE KINGDOM,

INCLUDING THE

STRUCTURE, FUNCTIONS, AND PHENOMENA,

NATURAL AND CHEMICAL, OF PLANTS.

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PART I.

Chap. III.—OF THE STEM OR STALK.

PART III.

CORRIGENDA.

Preface, page 19, 1st line, for *their*, read *the.*

Page 75, third line from the top, for *devacuated*, read *divaricated.*

Page 91, last line of note, for *Phellandrum*, read *Phellandrium.*

Page 96, fifth line from top (21) for *Monœau*, read *Monœcia*

The same, Class 23, for *Polyamia*, read *Polygamia.*

Page 98, 1st line, for *Polydelphia*, read *Polyadelphia.*

Page 100, third line from the bottom, for *Pencarp*, read *Pericarp.*

Page 100, third line from the bottom (*b*). for *Angoispermia*, read *Angiospermia.*

Page 109, fourth line from the bottom, for *Pomanum*, read *Pomarium.*

Page 109, third line below Ex. for *Libaceous*, read *Liliaceous.*

Page 113, third line from the bottom, for *Vividis*, read *Viridis.*

DESCRIPTION OF PLATE I.

Roots, see p. 23.

Fig. 1. Spindle-shaped, or fusiform root, as that of the *Carrot.*
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———— *b.* Peduncle or flower stalk.
———— *c.* Petiole, a leaf.
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—— 16. Roundish.
—— 17. Egg-shaped, or ovate.
—— 18. Oval.
—— 19. Oblong.
—— 20. Spear-shaped, or lanceolate.

Fig. 21. Spatulate.
—— 22. Wedge-shaped.
—— 23. Linear.
—— 24. Awl-shaped, or sabulate.
—— 25. Kidney-shaped, or reniform.
—— 26. Heart-shaped, or cordate.
—— 27. Crescent-shaped or lunulate.
—— 28. Triangular.

Leaves in general are named according to the resemblance they bear in shape to various material objects; also from various peculiar habitudes, &c. e.g.

Stellate, or star-shaped. *Peltate* or target-shaped. *Palmate*, or hand-shaped. *Sessile*, or sitting. *Decurrent*, or running downward. *Perfoliate*, when the stalk passes through the substance of the leaf. *Imbricated*, when they lie over each other, like the tiles of a house. *Fasciculated*, when many leaves rise nearly from the same point, as in the larch, &c. &c.

Corolla *.

Fig. 29. Bell-shaped, or campanulate.
—— 30. Cruciform, or cross-shaped.
—— 31. *a*. Cap or pileus. *Calyx*.
b. Curtain, or annulets.
—— 32. Spine or thorn; this grows out of the woody substance of a plant.

Fig. 33. Aculeus, or pricker, is formed from the bark.

* The corolla, like the leaves, are denominated after the shape or resemblance they bear to other objects: e.g. Funnel-shaped corolla, as *tobacco*. Salver-shaped, wheel-shaped. Ringent or gaping. Cruciform, &c.

SPECIMENS OF POISONOUS PLANTS.

Pub.^d by Jas. Bulcock. 163, Strand.

CLASSES, see p. 94.

Stamens, *a*. *Pistils*, *b*.

—— 34. Cl. 1. Monandria.
—— 35. — 2. Decandria.
—— 36. — 3. Triandria.
—— 37. — 4. Tetandria.
—— 38. — 5. Pentandria.
—— 39. — 6. Hexandria.

Orders, see p. 99.

*** Further description may be more profitably collected from natural objects, under this and the preceding heads, where individual plants have generally been referred to.

[*For Plate* II. *see p.* 63, *&c. &c.*]

EXPLANATION OF PLATE III.

[*Fronting Title page.*]

Fig. 1. THORN APPLE. *(Datura Stramonium)* *Class V*. Order 1. Monogynia. *Natural Order*. LURIDÆ. *Lin.* Solaneæ, *Juss.*

GENERIC CHARACTER. *Corolla*, funnel-shaped, plaited. *Calyx*, tubular, angular, deciduous. *Capsule*, 2-celled, 4-valved.

SPECIFIC CHARACTER. *Pericarps*, spinous, ovate, erect. *Leaves*, ovate, glabrous.

Fig. 2. DEADLY NIGHTSHADE. *(Atropa Belladonna.)* *Class V*. PENTANDRIA.—Order I. MONOGYNIA. *Nat. Order*. LURIDÆ. *Lin.* Solaneæ. *Juss.*

GEN. CHAR. *Corolla*, Bell-shaped. *Stamens*, distant. Berry, globular, 2-celled.

SPEC. CHAR. *Stem*, herbaceous. *Leaves*, ovate, entire.

Fig. 3. MEADOW SAFFRON. *(Colchicum.)* Class VI. Hexandria, Order III. Trygynia.

Gen. Char. Calyx non. *Corolla*, one petal, tubular, Capsules III. inflated, many-seeded.

Spec. Char. Leaves smooth, lanceolate, erect. *Corolla*, oblong jagged.

Fig. 4. WATER HEMLOCK. *(Cicuta).* Class V. Pentandria, Order, Digynia.

Gen. Char. Fruit, roundish, corded at the base with six ribs. Calyx dilated, acute, unequal. Petals ovate, nearly equal. Styles slightly tumid at the base. Flowers unequal, irregular, fertile.

Spec. Char. *Leaves* bi-ternate, follicle, linear, lanceolate, decurrent.

Fig. 5. FOXGLOVE. *(Digitalis purpurea.)* Class XIV. Didynamia. Order II. Angiospermia *Nat. Ord.* Luridæ, *Lin.* Scrophulariæ, *Juss.*

Gen. Char. Calyx 5-partite. *Corolla*, bell-shaped, 5-lobed, ventricose beneath, capsule ovate, 2-celled.

Spec. Char. Segments of the calyx ovate, acute. *Corolla*, obtuse, upper lip undivided; leaves downy.

Fig. 6. BLACK OR COMMON HENBANE. *Hyoscyamus Niger.* Class V. Pentandria. Order I. Monogynia. *Nat. Ord.* Luridæ. *Lin.* Solaneæ. *Juss.*

Gen. Char. *Corolla*, funnel-shaped, the lobes obtuse. *Stigma*, capitate. *Capsule*, covered with a lid, 2-celled.

Spec. Char. *Leaves* sinuate, amplexicaul ; flowers sessile

*** The above plants are illustrated from that no less elegant than useful work "Medical Botany," edited by Dr. Stephenson, and Mr. J. M. Churchill.

PREFACE.

The object of the "First Lines of Botany" is to initiate the young botanist, and such as have no distinct botanical ideas, to the general study of this useful and pleasing science, principally through the medium of the book of nature; by referring the student to objects within his reach, instead of abstracting his conceptions by indifferently executed engravings, known only to represent some natural object by the precaution taken to have the name of the individual attached to it; for those who are only book botanists will but indifferently avail themselves of knowledge thus acquired in a practical point of view.

The baby system of education, as old as Adam, called the 'Interrogative,' hitherto so slavishly enforced and patiently endured, as regards the higher order of the sciences, has nothing to recommend it, not even simplifi-

cation of ideas; on the contrary, there is much to condemn in its indiscriminate application; and in most instances it is inferior, as a channel of communicating the elements of general knowledge, to the usual methods of plain, analytical, and rational display. To children of tender age, indeed, it may possess some advantages, when the subjects are suited to their years and capacity. In these cases it appears plausible enough to connect a string of monotonous laconisms, in the shape of continued question and answer; but where no distinctions are drawn between an infantile and a mature mind—the idea is as ridiculous as absurd.

In the present instance, without having servilely adopted or entirely rejected the interrogative method, we have used it rather as an occasional diverticulum, as well as a kind of starting post for a fresh subject.

Another method of attempting to convey the elements of science, if any thing more

objectionable than the ring of changes so peculiarly characteristic of the unmodified interrogative system, in consequence of its being more quaint and affected, is that which is thrust forward in the conversational or epistolatory style, by people indifferently acquainted with the sciences they would thereby promulgate; and even in the best hands, there is something in this method at which the unassuming, industrious, and inquisitive mind recoils; and more particularly when forced, as it were, to draw, through such equivocal channels, upon the fictitious correspondence of some garrulous old woman or pedantic spinster, for the higher order of elementary knowledge, when more intelligible narrative and arrangement would answer the purpose much better, and be more cordially received.

In the elementary works hitherto extant, constructed on the above plans, systematic arrangement, for the most part, is evidently disregarded. It might appear invidious here to make allusions; but it is almost needless, in

the present state of knowledge, to urge the necessity of a method, particularly in the study of nature; it is the very soul of science; and all attempts towards the acquisition of knowledge without it, must end in uncertainty and confusion. It is this want of method, in an elementary point of view, which we have here also attempted to correct; by tracing 'the first lines of Botany,' in the following simplified and systematic manner; in order to facilitate the introduction to a general knowledge of the science, through the medium of an agreeable and instructive series of connexions, leading the student, link by link, almost imperceptibly, to the acquisition of his object; which embraces a general acquaintance with the vegetable kingdom, the clear understanding of all botanical writers and systems, but more particularly that of Linnæus, which is now almost universally received, and which has gained its author immortal honours.

THE AUTHOR.

Nov. 20th, 1827.

INTRODUCTORY

INVITATION TO THE STUDY

OF

BOTANY.

Among all the studies which occupy the mind of man, few are attended with circumstances equally pleasing in their pursuit; few can boast that infinite variety of objects which are perpetually engaging our attention, and inviting us to pleasures equally rational and innocent, as Botany. It is a science which has been cultivated by the wisest of mankind, and particularly by the professors of the medical art. Nor is it by any means

limited to particular professions. Every one, in fact, ought to be so well founded in the principles of botanical knowledge, as to be acquainted with the name and history of plants, as to be capable of finding their names in the system; and to describe each scientifically, whether it be used in diet or in medicine.

Notwithstanding the importance of this science in a branch of medical knowledge, it is much to be regretted that it is so little attended to by gentlemen of the faculty in this country—indeed so much so, that it obliges them to depend on the pretended skill of the ignorant and illiterate for many of their efficacious officinal plants, frequently at the expense of their own character, and of all that is valuable to their patients. But it is not to physic alone that botany is subservient, as it may be applied with considerable advantage to gardening, and the general purposes of agriculture, as to any other science.

"In this enlightened age," says an eminent botanist, "when arts and sciences are carried to a pitch unthought of in former times, we might expect a nation celebrated not less for its arts than its arms, would be the first to promote a science, whose improvements are the only solid check to the baneful and enervating effects of luxury and dissipation; and accordingly we find many of our nobility, gentlemen of landed property, and public societies, fully aware of its importance, and endeavouring by premiums, and a variety of other means to improve it." Much, however, still remains to be done; nor is it probable that their endeavours will be crowned with success, till botany is more generally cultivated, and plants, particularly the grasses, better understood. Hence the difficulty which many of our modern writers in agriculture have to encounter, in communicating their discoveries, for want of botanic information; by so much the more is the pro-

gress of this most useful science retarded as must be obvious to all who have perused their writings with any degree of attention.

Independent also of exalting our conceptions of the supreme Being, and of leading us directly to the knowledge of causes and effects, so well exemplified in the vegetable world, the advantages resulting from a knowledge of botany is self-evident; for, whoever has turned his mind so as to comprehend the extensive system of the vegetable kingdom, in the manner as at present taught, and has traced this system through its various connections and relations, either descending from generals to particulars, or ascending by a gradual progress from individuals to classes, till it embraces the whole vegetable world, will, by the mere exercise of the faculties employed for this purpose, acquire a habit of arrangement, a perception of order, of distinction and subordination, which is not perhaps in

the nature of any other study so effectually to bestow.

In this view, the examination of the vegetable kingdom seems peculiarly proper for *youth*, to whose imperverted minds the study of natural objects is always an interesting occupation, and who will not only find in this employment an innocent and an healthful amusement, but will familiarise themselves to that regulated train of ideas, that perception of relation between parts and the whole, which is of use, not only in the pursuit of this delightful study, but in all the concerns of life.

Independent too of the habits of order and arrangement which will be thus established, it may justly be observed, that the bodily senses are highly improved by that accuracy and observation, which are necessary to discriminate the various objects that pass in

review before them. This improvement may be carried to a degree of which those who are inattentive to it have no idea. The sight of Linnæus was so penetrating, that he is said never to have used a glass, even in his minutest enquiries. And there is a striking instance of an individual, who, although wholly deprived of sight, has improved his other senses, his touch, his smell, and his taste, to such a degree, as to distinguish all the native plants of this country, with an accuracy not attained by many of those who have the advantages of sight, and which justly entitles him to rank among the first botanists of the kingdom*.

Independent of the propriety of the *creature* admiring the works of his beneficent *Creator*, and of the advantages resulting to the individual who attaches himself to this

* Mr. Gough, of Kendal, alluded to by Roscoe, in his address at the opening of the botanical garden, at Liverpool.

study, "as enlarging the understanding, and rendering his mind more orderly in every concern of life, and his senses more acute," he will find also that there results from the pursuit of botany, the most heartfelt satisfaction.

The botanist at every walk, and on every excursion, pleasantly glides from object to object, each flower he reviews excites in him curiosity and interest; and as soon as he comprehends the *manner* of its *structure*, and the rank it holds in a *system*, he enjoys an unalloyed pleasure, not less vivid, because it costs him no great expense or trouble. In this occupation it is that the violent passions are lulled into a dead calm, and only so much of emotion is produced as is sufficient to render life happy and agreeable.

Plants even present themselves for our regards; they charm us by the beauty of

their forms, the richness of their shades, and the pleasure they spread around our habitations; they alone afford delight, without leaving behind any inquietude. The heart overwhelmed with grief, the sight fatigued by exertion, find in the verdure of fields, adorned with flowers, both comfort and refreshment. For us the rose kindly unfolds to our view her smiling colours. The pink at the same time flatters our sight and our smell by its agreeable emanations. A thousand other flowers, of different forms, every moment present themselves to our notice. Fruit trees, after gratifying our sight, deposit into our hands the most delicious food. The waving corn and golden sheaths delight every heart. We meet with other kindly vegetables, which can assuage our pain and cure our maladies. In vegetables we discover the foundation of the linen which we wear, of the paper which hands down to us the wisdom of ages—those *dyes* which im-

press on our garments their brilliant colours. To plants we are indebted to the wood which warms us in Winter, kindling into a blaze, resembling the sun we seem not now to want. Without timber, our houses could scarcely have been constructed; which, when fashioned into ships, the world, which before was separated from us, with its produce, by a vast expanse of water, is now approached even to our very chambers. "Hence," as Senebier observes, "I behold with still greater veneration those *trees*, whose stout branches diverge on every side, yet possessing a foliage which agreeably quivers to every breeze, but whose massy trunks shew an existence throughout ages. Under their vast shadows, listening to the songs of the inhabitants of the groves, I repose myself; leaving this retreat, I next tread over a *rich carpet of innumerable flowers, whose varied enamel yet fixes the tender regards of that old man, who has so much and so often admired it in his youth.*"

The beauties of nature, even those which feast the intellectual eye, are inexhaustible. So vast a profusion of beauty, contrivance, and design, as is seen exhibited by nature, multiplies greatly the inlets to knowledge and to happiness. The inimitable Hervey, after having meditated among the tombs, and descanted upon the starry heavens, then treats the world with his "reflections upon a flower garden :—

" *Here*," says he, " NATURE always pleasing, every where lovely, appears with particular attractions. *Yonder*, she seems dressed in her dishabille ; grand, but irregular. Here she calls in her handmaid art, and shines in all the delicate ornaments which the nicest cultivation is able to convey. *Those* are her common apartments where she lodges her ordinary guests ; *this* is her cabinet of curiosities, where she entertains

her intimate acquaintance. My eye shall often expatiate over those scenes of universal fertility; my feet shall sometimes brush through the thicket, or traverse the lawn, or stroll along the forest glade: but to this *delightful retreat* shall be my chief resort. *Thither* will I make excursions, but *here* will I dwell.

"What sweets are these, which so agreeably salute my nostrils? They are the breath of the flowers; the incense of the garden. How liberally does the jessamine dispense her odoriferous riches! How deliciously has the woodbine embalmed this morning walk! The air is all perfume. And is not this another most engaging argument, to forsake the bed of sloth? Who would lie dissolved in senseless slumber, while so many breathing sweets invite him to a feast of fragrancy; especially considering that the advancing day will exhale the volatile dain-

ties? A fugitive treat they are, prepared only for the wakeful and industrious. Whereas, when the sluggard lifts his heavy eyes, the flowers will droop; their fine scents will be dissipated; and, instead of this refreshing humidity, the air will become a kind of liquid fire."

"Awake, the morning shines, and the fresh field
Calls you: ye lose the prime, to mark how spring
The tended plants, how blows the citron grove;
What drops the myrrh, and what the balmy reed;
How nature paints her colour; how the bee
Sits on the bloom, extracting liquid sweets." MILTON.

"How delightful is this *fragrance!* It is distributed in the nicest proportion; neither so strong as to oppress the organs, nor so faint as to elude them." What an enchanting situation is this! One can scarcely be melancholy within the atmosphere of flowers. Such lively hues, and delicious odours, not only address themselves agreeably to the senses, but with a surprising delicacy, the sweetest emotion of the mind."

As regards the appearance of plants, the inspection of the botanist subtracts nothing from the delight which the flowers impart; on the contrary, his wonder, his admiration, its fragrance, is increased by the minute examination of these fair and exquisite productions of nature. For the more closely nature is scrutinized, the more she gains by a new acquaintance, and the more reason she affords for the admiration of her inimitable perfections. Hill and dale, broad expanse of water, luxuriant verdure; the variety of seasons, with their successive productions, forming, as it were, a diversified *drama*, a continually *shifting scene*, which never cloys, but always delights, must at first have captivated the attention of man, even the most barbarous or least instructed. For the botanist there is no solitude wherein he wanders, he finds food for his genius in the abundant resources of nature. He is always surrounded with agreeable and inviting

companions which ever keep his interest alive. The book of nature is ever open to him in his botanical excursions; he acquires knowledge, health, and strength; he feels an inward solace which no other pursuit can afford him; his enjoyments are pure and intellectual; his mind calm and serene; above all, the fittest moments to contemplate the divinity and admire his providence.

Plants appear to have been profusely scattered over the earth, as the stars in the firmament, to invite man, by the attractions of curiosity and pleasure, to *their* contemplation. But the stars of heaven are placed at a distance from us. To possess this information requires a previous knowledge and acquaintance with the mathematics—instruments, machines, a long artificial ladder, to bring them within our scope. *Plants,* on the contrary, grow under our feet, and seem to *invite* our hands; and if the minuteness

of their instruments for their examination are comparatively trifling—a needle and a magnifying glass, or at most, a pocket microscope, is all the apparatus required. The botanist, at every walk, pleasantly glides from object to object—each flower he reviews excites in him curiosity and interest; and as soon as he comprehends the *manner* of its *structure*, and the rank it holds in a *system*, he enjoys an unalloyed pleasure, not less vivid, because it costs him no expense or trouble. Before, however, the sentimental enjoyments of botanical pursuits can be fully appreciated, some knowledge of this delightful study must be acquired. We shall now, therefore, proceed in our elementary detail, in the most simplified manner, as best calculated to promote the desired object, by entering at once on the plan we have already proposed.

PART I.

CHAPTER I.

BOTANY.

Q. Explain, if you please, in terms as brief as explicit, in what the science of botany is made to consist.

A. The science of botany treats of the nature and properties of vegetables; shewing also how to ascertain the name of any plant which may happen to fall in our way.

PLANTS.

Q. How is a plant usually distinguished?

A. As an organized body, consisting of five principal parts, e. g:

1. Root.
2. The stem.
3. The leaves.
4. The branches.
5. The flower.

Q. What is the common division of plants, as regards their appearance and reproduction?

A. Into annuals, biennials, and perennials.

Q. Describe the annuals.

A. The annuals are those which last but one year, viz. those which grow up in the Spring and die in the Autumn, as wheat and barley.

Q. What is to be understood by a biennial plant?

A. Biennials are those which produce flowers, and seed the second year after being raised, and then die; as the leek and the canterbury bells.

Q. And pray, what are perennial plants?

A. Perennials are those, the roots of which last for many years; and are of two kinds, the one retaining their leaves all the Winter, called *evergreens,* as the laurel; and the other casting them, called *deciduous,* as the apple-tree. These again are subdivided, according to their magnitude or other circumstances; and are either called trees, shrubs, or herbs.

Q. In what do trees differ from shrubs or herbs?

A. Trees consist of a single trunk, out of

which shoot branches, as the oak; they are also the largest productions of the vegetable kingdom.

Q. What is a shrub? and how is it characterized?

A. They are a smaller production than trees, and instead of a single trunk, they frequently send forth many sets of stems from the same root, as the honey-suckle.

Q. And what are we to understand by herbs?

A. Herbs are those plants which, like the snow-drop, die away every year after the seed is ripe.

CHAPTER II.

THE ROOT.

Q. How is the root defined?

A. The root is the principal organ of nutrition; it feeds upon the earth, to which it attaches itself; and thus conveys the vegetable

aliment to the fabric depending upon it for growth, &c.

Q. How are the roots of plants usually divided?

A. Into five sets, viz.—

1. *Spindle-shaped,* or that kind which, as its name implies, tapers gradually, from the base or collar, to the apex, or conical point of the plant, as exemplified in the carrot and parsnip.

2. *The bitten or truncated root,* or that kind which, like the spindle shaped, tapers gradually, but terminates abruptly, as if the lower part had been cut or bitten off; and of which the devil's bit, or scabious, affords a specimen.

3. *The fibrous* or *capillary roots,* are those consisting of a number of small and thread-like fibres, one of which is generally central, and the rest lateral; and which support the plant not by their individual strength, but by their number and distribution; elongating in a divergent direction, and rivetting down the plant on all sides, e. g. the roots of *trees,* those of the *primrose, wheat, oats, barley,* and the generality of the *grasses.*

4. *The bulbous roots,* or those species which consist of one globe or head, sending out fibres from the bottom, e. g. the *crocus, hyacinth, narcissus, snow-drops, lily,* &c. Botanical writers mention three kinds of bulbous roots, namely, the solid, or those of one solid substance, as the *turnip;* the *scaly,* or those bearing scales, of which that of the lily is a specimen; and the *coated,* or those having layers, or coats one over another, as exemplified in the onion.

5. *The tuberous,* or those roots which consist of a knot or tubercle, furnished with a number of small or scattered fibres, or of a number of knots or tubercles, united by the means of such fibres, and forming clusters, e. g. in the *potatoe, earth nut, peony,* and *white saxifrage.*

Obs. With regard to the term *bulbous root,* some difference of opinion has existed among botanists as to its propriety; for, in fact, the bulb merely contains the rudiments of a future plant; and the fibres issuing from the under surface of the bulb are the only true and efficient root; and to prove that the fibres are the only perfect root, if they be cut away the bulb will

not germinate. Hence it appears that a bulbous root is, in short, only a fibrous root, with the addition of a bulb, which is very properly considered as the *hybernaculum* * of the plant.

In some instances fibrous roots become bulbous. Thus the *meadow-cats,* when growing in a moist soil, which it naturally affects, is uniformly furnished with a fibrous net; but when growing in a dry situation, where it is also often to be found, it has a bulbous root. Also the *knee-jointed fox-tail grass,* when growing in its native marshes, has a fibrous root; but when found in a very dry situation, as on the top of a dry wall, it is furnished with an *ovate* and juicy bulb.

DIVISION AND DISTINCTION OF ROOTS.

Q. How many parts are roots generally divided into?

A. Into two, viz. the *caudex* or great root, and the *radicula,* or little root.

Q. Describe the caudex.

* Vide Botanical Glossary.

A. The caudex, or great root, is the main part of the root in trees and plants that live for many years; is generally woody; and is to the other parts what the trunk or stem is to the branches or bows; it enlarges progressively in a similar manner, and gives off lateral branching shoots, which spread horizontally, i. e. in a direction which forms nearly a right angle with the caudex.

Obs. In many annuals, and in those plants in which the herbaceous part dies, whilst the root survives; the caudex is also a reservoir of nutriment, which is intended for the renewal of the herbaceous part in the following season, or to be expended in perfecting the flower and seed.

Q. Describe the radiculæ, or rootlets.

A. The rootlets, or little roots, are small, or thread-like productions, proceeding from the caudex, and terminating in exceedingly minute fibrils, which are real absorbing organs of the root.

Q. On what are the botanical distinctions of roots founded?

A. On six particular points, viz. 1. Their situ-

ation. 2. Direction. 3. Deviation. 4. Substance. 5. Form. 6. Composition.

Q. What is meant by their situation?

A. This refers to the place or soil to which they are attached, and which may be said to be 1. *Subterraneous*; 2. *Aerial*; 3. *Floating, and* 4. *Parasitical;* which are explained as follows:—

1. *Subterraneous,* when they are in the ground, as with *snow-drops,* and most plants.

2. *Aerial,* when they are neither attached to the ground, nor any other substitute, but suspended in the air; as with the *Indian fig* and *aerial flower.*

3. *Floating,* when the root has germinated in the soil, separates, and floats upon the surface of the water, as with the common *duck weed.*

4. *Parasitical,* when they are attached to the bark of other living plants; as with the misletoe.

Q. How are roots distinguished relative to the direction they take?

A. 1. As being *perpendicular,* i. e. when the

caudex or main body of the root extends perpendicularly into the ground, as in most trees.

2. As *horizontal,* when the extension is nearly parallel to the plane of the horizon, so that the roots form nearly a right angle with the stem or herbaceous part of the plant, e. g. in *winter green,* and sweet flag.

3. As *oblique,* as when the root takes an intermediate direction, i. e. between the perpendicular and the horizontal.

Q. What terms are applied to roots as regards their duration ?

A. Those already explained (see page, 27.); viz., annual biennial, and perennial.

Q. In what light are they considered when their substance becomes a mark of distinction ?

A. As being either of a woody or of a fleshy nature.

Woody, when composed of an epidermis, a bark, a vascular system, woody matter, and pith, as with trees and shrubs.

Fleshy, when they belong to herbaceous plants, consist chiefly of cellular and vascular textures,

interspersed with slender bundles of woody fibre, as with the snow-drops, lily, hyacinth, and narcissus.

Q. Explain what is meant by the form and composition of the root.

A. By the form and composition of the root are implied the figure they assume, and the parts which constitute that figure. As regards these, roots are either simple, branched or articulated, e. g.

1. *Simple,* when they consist of either a single caudex furnished with fibres only, or of one or more rootlets with fibrils, as in the roots of the *carrot, parsnip, horse-radish, dandelion, radish, and primrose.*

2. *Branched,* consisting of a caudex, divided into lateral branches, which are again subdivided, and ultimately terminated in absorbing fibrils, so that the root in its division resembles the stem and branches inverted. This form of root is the most general, being that of all trees and shrubs, as well as that of many herbaceous plants, e. g. *elecampane* and *seneka.*

3 *Articulated,* i. e. apparently formed of dis-

tinct pieces, united as if one piece grew out of another, so as to form a connected whole, with rootlets springing from each joint, as with wild ginger, *hedge-hyssop, Solomon's seal,* and *bistort.*

RECAPITULATORY OBSERVATIONS.

The caudex, or main root, consists of the same parts as those met with in the stem of the tree, arranged in the same relative order, and each part, when placed under the microscope, displays nearly the same structure as the corresponding part above ground.

The rootlets consist of a spongy centre, resembling the medullary sheath divested of spinal vessels, surrounded by a circle of ligneous fibres, and with a bark much thicker than that of any part above the soil.

The fibrils are apparently a production of the bark of the rootlets, with a few ligneous vessels shooting into their centre. Whatever may be their structure, their pores are evidently the absorbent mouths of the root, possessing either a valvular apparatus, or a power of contracting strongly, so as to enable them to retain the fluid

they imbibe, until it be taken up by the ligneous vessels. Not that the herbaceous root bears so close an analogy to the stem, as this arises in many instances from the difference in the duration of the top of these parts in herbaceous plants; for the root may be *perennial* or *biennial* when the stem or stone are *annual* only, or dying in the Autumn, and giving place to others, which shoot up from the same root in the succeeding Spring.

Circumstances which materially affect the root. The life both of the annual and biennial roots may occasionally be protracted considerably beyond their natural period, when any circumstance occurs that may prevent the plant from flowering, or, in fact, when it actually does flower, from having perfected its seed,

Use and properties of roots. In Keith's system of Physiological Botany, the root is considered as the mouth of the plant, selecting what is useful for its nutrition, and rejecting that which is yet in a crude and indigestible state. The larger portions of the root serve to fix the plant in the soil, and to convey to the trunk the nutritive

particles absorbed by the smaller fibres, which ascending by the tubes of the alburnum, is conveyed to the leaves, which are the digestive organs of plants.

Like the trunk of plants, the roots will not thrive when wholly deprived of the atmospheric air;—hence, in all probability, they inhale it by their epidermis, though the pores by which it enters may be invisible, or that it enters into combination with the nourishment of the soil.

As regards the *enlargement* of the roots of plants, observation and experiment prove that, at least, those of woody plants are increased in width, by the addition of an annual layer, and in length, by the addition of an annual shoot, bursting forth from the terminating fibre.

The original direction of the growth of vegetable roots is generally perpendicular; but if they meet with any obstacle, they then take an horizontal one, not by the bending of the original shoot, but by sending out lateral shoots. The same result ensues, when the extremity of the root is cut off.

Experiment. Du Hamel caused some cherry stones, almonds and acorns, to germinate in wet sponges, and when the roots had grown to the length of two inches, he placed them in glasses, as bulbous roots are placed, so as that the extremity of the root only touches the water. Some were previously shortened by the cutting off of a small piece from the point, others were put in entire. The former sent out lateral shoots, but elongated no farther in a perpendicular direction; the latter descended perpendicularly to the bottom of the glass. He cut off also the tips of some roots vegetating in the earth, and had the same result: the wound cicatrized, and the root sent out lateral divisions.

CHAPTER III.

OF THE STEM OR STALK.

Q. Explain, if you please, what is meant by stem or stalk of a plant, which, as already observed, is stated to be its second grand division,

A. The stem or stalk is that part of a plant arising immediately from the root, supporting the branches and other appendages.

Q. How many kinds of stems or trunks are there? and how are they designated?

A. Five, viz., 1. A trunk. 2. A stalk. 3. A straw. 4. A scape. 5. A stipe, which are individually designated as follows:—

1. *A trunk* is the proper stem of trees and shrubs, characterized by its woody structure, by being always perennial, generally naked at the lower part; divided and subdivided toward the summit into branches and twigs, bearing leaves and the fruit.

2. *The stalk* means the stem of herbaceous plants only. Its structure is seldom woody; and it lives but one or two years in the natural state of the plant.

3. *The straw*, or *culm*, is the peculiar stem of grasses, rushes, and other similar plants; it is either hollow, or partially filled with pith; and generally knotted, articulated and knee'd, but very seldom branched.

4. *A scape* is that peculiar stem arising from

the root, which supports the flower but not the leaf. It is always herbaceous, and is either simple and bearing one flower only, as in the common *dandelion,* or divided and many flowered, as in the *cowslip.*

5. *A stipe* is the term used to express the stem of palms, ferns, fuci, and fungi. It is generally cylindrical, sometimes swollen in the middle, and bears a frond, or the foliage which is peculiar to it, at its summit.

STRUCTURE OF STEMS.

Q. Of what does the structure of vegetable stems consist?

A. These are formed of a number of fine capillary tubes, through which, during their growth, sap is sent from the root throughout the entire plant. By most botanists stems are made to consist of six organic parts, viz.—

1. The epidermis, which is the external envelope or integument of the plant, which extends not only over the trunk, but likewise over the root, branches, leaves, flower, and fruit, including

their appendages, with the exception of the summit of the pistil. Du Hamel, who was the first to direct any very minute investigation into the structure of the vegetable epidermis, describes it as formed of a multiplicity of fine and delicate fibres placed in a parallel direction, inosculated or united at regular intervals, by means of small and lateral fibres, so as to constitute a net-work, the meshes of which are filled with a thin and transparent pellicle, thus forming a membrane consisting either of a simple and individual layer, as in the epidermis of most plants, or of several distinct and separate or separable layers, as in that of the paper birch, in which he counted six more.

Obs. In the permanent parts of woody and perennial plants, the old epidermis often disengages itself spontaneously, as in the currant, birch, and plane tree, in which it is apparently undergoing a continual waste and repair; and in such parts it is again regenerated, even though destroyed by accident. But in herbaceous plants, and in the leaf, flower and fruit of other parts, it never disengages itself sponta-

neously, nor is it ever reproduced when once destroyed.

2. and 3. *The inner and outer bark* are those parts situated immediately beneath the epidermis, which are generally of a spongy nature.

4. *The alburnum* is the soft white substance lying between the inner bark and wood. In the course of time it acquires solidity, soon becoming wood itself; but while soft it performs a very important part of the functions of growth, which ceases when it becomes hard.

Obs. A fresh circle of alburnum is annually formed over the old, so that a transverse section of the trunk presents a tolerably correct register of the age of the tree, by reckoning each zone for a year.

5. *The wood* is the part between the alburnum and pith, which, notwithstanding its solidity and compactness, will be found, by means of the microscope, to be an assemblage of infinitely small canals or hollow tubes.

PITH OF PLANTS.

Q. How is the pith of plants described?

A. The pith is that soft spongy substance found in the central parts of plants, which is compressed and straightened, as the substance of the trunk becomes more woody, to such a degree that it ultimately disappears.

Obs. The diameter of the pith, in some plants, is large in proportion to the stem, as, for instance, in the fig, elder, and sumach; whilst in others, it is scarcely perceptible, as in the oak and elm.

Q. Has every species of trunk all these individual plants?

A. Not the whole of them, as may be observed by examining the straw of grapes, and the stalks of the primrose, narcissus, and hyacinth; but all kinds of trunks possesses some of these peculiar characteristics, or at least a modification of them.

DISTINCTIONS OF STEMS.

Stems are considered botanically, in the description of plants, according to their

Composition, Form,

Direction,	Manner of branching,
Duration,	and
Substance,	Surface.

Q. How are stems termed as regards their composition?

A. Either simple or divided.

1. *Simple,* consisting of one piece only, without any branches bearing leaves, although the flower may be divided; as may be seen in the bistort, date-plum, and knotty-rooted figwort.

2. *Divided,* when the stem divides into branches, as in most plants.

Q. What terms are used to denote the direction of the stem?

A. The following six, viz. erect, oblique, supported, climbing, decumbent, and procumbent, illustrated in the following manner:—

1. *Erect,* when its position forms nearly a right angle with the surface of a level soil. It may be *straight,* as in the spearmint and silver fir; *flexuous,* as in the box-leaved staff tree and common birthwort; *tortuous,* when it is curved in different directions, but not regularly, as in

the flexuous stems; or nodding, as in the cedar and Solomon's seal.

2. *Oblique,* when between a perpendicular and an horizontal position. It may be *ascending,* as in the common clover and common toad-flax; *declined,* as in the fig-tree; or *incurvated,* as in the common bramble.

3. *Supported,* or propped up, as it were, by a number of other stems that surround it, which incline towards each other at their summits, until they seem ingrafted into the base of the stem which they support, as in the mangrove.

4. *Climbing,* as those which are too delicate to support themselves. These require the aid of some perpendicular body to enable them to elevate their foliage and fructification in the air. Hence, they are either *twining* from left to right, as in the woodbine and the hop; or from right to left, as in the scarlet bean and great bindweed; *radiating,* as in the ivy and ash-leaved trumpet flower; *climbing,* as in the grape vine, purple virgin's bower; bitter-sweet, and all the species of passion flower.

5. *Decumbent,* as when it rises a little upright

at its base, but has its upper portion bent down towards the ground, so that the greater part of it is procumbent.

6. *Procumbent*, as when the stem is too weak to support itself, and lies on the ground. These are either *creeping*, as in the lesser periwinkle and ground ivy; or *floating*, as in the floating club rush.

Q. How are stems considered relatively to their substance?

A. As consisting either of a woody or an herbaceous nature.

1. *Woody*, as those in which wood forms comparatively the greater part of their bulk. They are either *solid*, as in the oak; or *fibrous*, as in the cocoa nut tree.

2. *Herbaceous*, as those which contain a small portion of wood, but are composed chiefly of cellular substance. These are either *fleshy*, as in the common house leek, and most sea-weeds; *spongy*, as in Indian corn, great cat's tail, and the mushroom tribe; or *hollow*, as in the castor oil plant, the common dropwort, and almost all the grasses.

Q. How are the forms of stems described?

A. In the seven following ways, viz. round, semicircular, compressed, angled, knotted, jointed, and knee'd.

1. *Round,* having no angles, as in the thorn-apple, and changeable hydrangea.

2. *Semicircular,* or half round, that is, half round on one side, and flattish on the other.

3. *Compressed,* when the stem is flat, as in the flat stalked meadow grass and spleenwort.

4. *Angled,* when it has several acute angles in its circumference. It may be obtuse, and three, four, five, six, or many cornered; acute and triangular, four angled, five angled, six angled, multi-angled; or three sided, when there are three flat sides forming acute angles.

5. *Knotted,* when it is divided at intervals by swellings or knots, as in knotty crane's bill.

6. *Jointed,* composed of joints, or apparently distinct pieces, united at their ends.

7. *Knee'd,* (geniculatus,) when an articulated stem is more or less bent at each joint, as in the floating fox-tail grass, and three flower fescue grass.

Q. Does the manner in which branches appear give rise to any peculiar terms for the stem?

A. Yes. For instance, a stem is said to be dichatomous, trichotomous, slightly branched, much branched, and abruptly branched.

1. *Dichatomous*, or forked, when the divisions and subdivisions are, throughout, in bifurcations, as exemplified in corn, salad, petty spunge, and forked marvel of Peru.

2. *Trichotomous*, when, instead of being bifurcated, the divisions are trifid, as in the common marvel of Peru.

3. *Slightly branched*, when the number of divisions are comparatively few.

4. *Much branched*, when not only the greater divisions are numerous, but these again divided and subdivided without order, as in the elm and gooseberry bush.

5. *Abruptly branched*, when each branch, after terminating in flowers, produces a number of fresh roots, in a circular order, just from below the origin of those flowers, as in the naked flowered Azalea, and many of the Cape heaths.

Q. What are the terms used to distinguish the surface of stems and branches.

A. These may include the terms of *bare*, *covered*, and *rough*; each division being subject to considerable variation.

I. Bare, when the epidermis is perfectly free from appendages of every description, leaves, scales, spines, prickles, or any kind of pubescence. The varieties of which are—

1. *Shining*, when it glistens, as if varnished, as in shining crane's bill.

2. *Smooth*, when it is free from all kinds of roughness or hairiness, as in periwinkle.

3. *Even*, when throughout it is perfectly free from inequalities, as in the common white poppy.

4. *Punctured*, when it is covered with small yet visible perforations, either simple or surrounded at the orifice with a raised border, as in rue and perforated St. John's wort.

5. *Maculated*, or spotted, when it is marked with spots or blotches, as in hemlock.

6. *Leafless*, when it is altogether devoid of leaves, as in the dodder.

7. *Unarmed,* when devoid of prickles and spines.

8. *Extipulate,* when without stipules.

II. Covered, when the epidermis is clothed with some kind of appendage. The varieties of this are—

a. Leafy, when it is furnished with leaves from the base to the apex. When the stem passes through each leaf, it is denominated *perpliate,* as in yellow wort.

b. Winged, when the edges or angles are longitudinally expanded into leaf-like borders.

c. Sheathed, when it is embraced by the base of each leaf, as if by a sheath; as in the grasses and snake-weed.

d. Stipulated, when it is furnished with stipules at the axilla of each leaf, as in common vetch, and broad-leaved everlasting pea.

e. Tendril-bearing, when it bears tendrils, as in the passion-flower and grape vine.

f. Bulb-bearing, when it is studded with bulbs in the axilla of the leaves, as in bulbi-

ferous coral-wort, and in several of the lily tribe.

a. Spiny, when it is furnished with short spines, which are not productions of the bark, and consequently do not come off with it, as in common hawthorn and sloe-tree.

b. Prickly, when it is covered with sharp-pointed bodies, which separate with the epidermis, as in the rose.

c. Scaly, when it is more or less covered with leafy scales, closely applied to its surface, as in broom rape. When, however, the scales, instead of being succulent and leafy, are dry and membranaceous, this variety of the scaly stem is termed *ramentaceous,* as in the slender branched heath.

d. Pubescent, when it is covered with hair-like appendages. The pubescence varies very considerably according to varieties of soil, climate, and exposure; there are nevertheless determinate characteristics, which, more or less, always distinguish it even in its variations. The varieties of this subdivision are—

1. *The hairy*, or when the pubescence consists of rather long separate hairs, as in mouse-ear and meadow sage.

2. *Hispid*, when the hairs are stiff and bristly, as in borage and common viper bugloss.

3. *Downy*, when the hairs are soft to the touch, like down, and so matted together that the particular hairs cannot be distinguished, as in shepherd's club and round leaved crane's bill.

4. *Shaggy*, when the pubescence consists of long, soft hairs, as in villose speedwell, and downy hedge-nettle, and woolly horehound.

5. *Silky*, when the hairs are shining, and so arranged as to give the stem the appearance of being covered with silk.

Obs. *Instead of pubescence, the covering in some instances consists either of a dry, powdery, or a moist secretion. The dry are three in number, the moist two.*

e. *Hoary*, when the entire surface is strewed

over with a fine white dust, easily rubbed off, like the bloom of grapes, as exemplified in the dwarf shubbery orach.

f. Mealy, when the white powder is less minute, or is mealy, as in bird's eye primrose.

g. Glaucous, when the dust or bloom is of a bluish green, or a sea-green colour, as in palma christi, or castor oil plant.

h. Viscid, when it is covered with a clammy resinous exudation, as in the clammy catch fly.

i. Glutinous, when the exudation is adhesive, but instead of being resinous it is gummy or soluble in water, as in clammy primrose.

III. Rough, when they assume an unequal character.

k. Scabious, when the stem is thickly covered with small eminences, which are not visible, but can be felt on passing the finger over it, as in black knapweed.

l. Warty, when it is studded over with

small hard warts, which can be both seen and felt, as in the warty spindle tree.

m. Vesicular, when the roughness depends on a small elevation of the epidermis, containing a watery fluid, which gives the plant the appearance as if it were covered with ice, as in the ice plant.

Obs. It ought here to be observed, that neither branches nor stems are essential organs to the vegetable structure, although they are so to the plants in which they are formed; for independent of some lichens, and many species belonging to their tribes of vegetables, which botanists have denominated imperfect, they are never present in many other vegetables, the foliage and fructification of which spring directly from the roots or some of its appendages; as, for instance, in the meadow saffron, stemless asphodel, and stemless artichoke. These plants are nevertheless perfect, and capable of performing all the functions necessary to their economy.

The stems of the same plants also occasionally differ, for it sometimes happens that in-

stead of assuming the cylindrical form common to the species, they are to be found compressed and flattened.

When the stem increases in thickness it is not by the enlargement of all its parts; but is augmented in width, as already mentioned, by the addition of an annual layer; and in length by the addition of an annual shoot bursting from the terminating bud. Though the development of the shoot issuing from the stem is not exactly performed in the same manner, but by the intro-susception of additional particles throughout its whole extent, at least in its soft and succulent state, the longitudinal extension diminishing in proportion as the shoot acquires solidity, and ceasing entirely when the wood is perfectly formed, though often continuing at the summit after it has ceased at the base.

Experiment.—Du Hamel divided a shoot of the horse-chesnut into several equal parts, distinguished by coloured varnish; and on inspecting it some time afterwards, found that all the marks were removed from one another to a greater distance than at first; but on inspecting it at a

second interval, he found that the upper marks only had continued to increase in distance. Hales made a number of similar experiments on the shoots of the vine, and obtained similar results.

Hence then it appears that the stem is evidently increased in length by the length of the terminating shoot, and in diameter by twice the thickness of the layer. If the induration be effected slow, then its growth is rapid; if it be effected rapidly, then its growth is slow; but the growth and induration of the plant are liable to be affected, both by soil and exposure to vicissitudes of the climate.

Q. How are unnatural distortions of the stem or bearers produced?

A. It sometimes happens that one side of the stem will remain in a state capable of extension longer than the other; hence the tree is liable to become deformed. Gardeners, however, correct or prevent this deformity by making a number of oblique incisions in the bark of the shoot on the side to which it is inclined, which,

by causing an eruption of the cellular tissue, brings it back again to an erect posture.

Q. In what manner is the growth of the stem influenced by the action of light?

A. In various manners; for instance, if a plant be placed in a room or cave in which there is only one small aperture for the admission of light, the stem will gradually bend towards that aperture, through which the light is admitted.

Q. Has light any influence over the vigour and colour of stems?

A. A very powerful one: for example, if the cutting of a potatoe is left to vegetate in a cellar, where there is little ingress to light and air, the stem would shoot out to an astonishing length in the direction of the light, but it will be found pale and limber, and trailing on the ground.

Experiment 1. Some French beans were sowed in a dark cave, with a view to ascertain the effect of the small portion of light transmitted to them through the entrance during the day, but it regained its erect position, at least partially so, during the night.

Experiment 2. Three beans were planted by Bonnet for the purpose of comparative experiment; one in the open air, another in a tube of glass covered at the top, and the third, in a tube of wood, covered at the top. The first plant was strong and luxuriant, the second was also strong, and inclined toward the sun, but the third, though tall, was pale and sickly.

CHAPTER IV.

ON THE LEAVES OF PLANTS.

Q. How do botanists define the leaf of a plant?

A. A leaf, botanically, is defined to be a part of a plant, extended into length and breadth, in such a manner as to have one side distinguishable from the other. Leaves are properly the extreme part of a branch, and the ornament of the twigs. They consist of a very glutinous matter, being furnished every where with veins and nerves.

Q. How are leaves usually divided?

A. 1. Into the base, or point, by which they

are attached to the plant; 2. The apex, or tapering terminating point; 3. The disk, or intermediate body of the expansion; 4. The boundary of the expansion or margin.

Obs. *The angle, which the leaf or its foot-stalk forms at its point of attachment to the stem or the branch, is termed its axilla. Many leaves are placed in a small stem or branch, and this part is called a leaf stalk.*

As a knowledge of the peculiarities attending leaves, in describing the species of plants, is of the greatest importance, botanists have paid particular attention to their names, which are derived from the following circumstance :—

1. The Situation.	8. The Base.
2. —— Direction.	9. —— Surface.
3. —— Duration.	10. —— Margin.
4. —— Distribution.	11. —— Pubescence.
5. —— Insertion.	12. —— Colon.
6. —— Expansion.	13. —— Substance.
7. —— Apex.	14. —— Productions.

Q. What are the terms originating from the situation of leaves?

A. Five, viz. radical, caulinear, rameal, seminal, and floral. (See Uses of leaves, &c. p. 75.)

PART II.

CHAPTER I.

VEGETATION, AND ITS FUNCTIONS, &c.

Vegetables are such natural bodies as grow and increase from parts organically formed, or serving as instruments to convey the principles of vegetative life; but have no proper life or sensation, such as plants, shrubs or trees.

Vegetative life, or vegetation, is the faculty or quality with which all plants are endued, by which they attract nourishment, or nutritious juices from the earth, and which, circulating through their substance, causes it to extend, unravel, or unfold its parts by degrees, until every part at length turns out in its proper form and site, and thus the plant is perfected.

Q. Do you say that the vegetable life and the

growth of plants and trees proceed from the juices of the earth, and not from the earth itself?

A. Yes.

In illustration of this assertion, Mr. Boyle found, by experiment, that a plant of three branches, and after that a plant of fourteen pounds weight, were produced from a quantity of earth, watered only with rain or spring water, which lost scarce any thing of their weight, being accurately weighed dry, before and after the production of the plants. A more convincing instance that plants receive their growth and weight from the moisture of the earth altogether, and not from the substance of the earth itself, is given by Van Helmont, who dried 200lb. of earth, in which he afterwards planted a willow weighing 5lb, which he watered with rain or distilled water, and to secure it from other earth getting amongst it, he covered it with a perforated tile cover. After five years he weighed the tree with all the leaves it had borne in that time, when he found it weighed 169 pounds

three ounces ; and the earth to have lost about two ounces of its weight *.

Q. How is the first generation or production of plants accounted for ?

A. All plants and vegetables are immediately produced and generated from some parent plant or vegetable seed, of the same species.

Q. How is this to be explained, seeing that plants have been often found to grow where seeds were never sown, or could come ?

A. This may be answered in three different ways :—

1. It is possible those plants may spring from seeds which may have been concealed in the earth in those places more than the age of man; for some seeds are known to retain their fecundity forty or fifty years.

2. They might spring from seed wafted thither by the wind, which, on account of its wonderful smallness, might escape detection.

3. These seeds might also be brought thither

* See also Dr. Woodward's experiments on this subject. Philosoph. Trans. No. 253. Harris' Lexicon, under the word "Vegetation," or in the Philosophical Library, under the word "Botany," page 437.

in the dung of animals at first, and so increase. Nothing however can be more effectually confuted than the atheistical doctrine of the spontaneous production*, or equivocal generation of plants or animals, in the works of modern naturalists.

* By the *spontaneous production* of plants is meant, their *growing*, as it were, of their own accord, or without seed; and this, in regard to animals, is called *equivocal generation*, whereby they are produced without parents *in coitu*. That this doctrine is *directly atheistical*, cannot admit of a doubt; for supposing the generation of some plants and animals to be spontaneous or casual, it is impossible to say but that the generation of all might have been so at first; and if the existence of any thing be casual, or proceeding from chance, it is certain all we can find in the nature or composition of such a being, must also be fortuitous, or by chance. And thus all the arguments derived from the wonderful mechanism of the whole, and the surprising structure of the several parts of *vegetable* and *animal* bodies (the two great magazines of natural religion) are utterly destroyed. This, however, is so notoriously contrary to common sense and reason as to require no refutation.

Indeed to those unacquainted with the use of the microscope, and have made no nice enquiry into the nature of things, but take every thing in a coarse and vulgar point of view, there may possibly appear some specious arguments for *spontaneous generation*; but those who are desirous to see them all confuted may consult Bentley's, Boyle's Lect. Sermon 4. Derham's Physico Theol. B. IV. Chap. 15, Note (1.) Watt's Philosoph. Essays, (Essay 9.)

Q. On the principle already stated, viz. that every plant is produced from the seed of a plant of the same species, give some explanation.

A. It is the doctrine of modern physiologists, that every seed has in itself what they call the *planta seminalis,* or *seed plant;* that is, the plant which is produced from the seed is really and formally contained in the seed (before it is sown), in miniature; and when the seed is sown, the parts of the *seed* plant, now in embryo, begin to vegetate, unfold, dilate, and at last burst the matrix seed, and thus swell out of its native bed of embryoanism.

Q. How, or by what means, were such nice investigations made?

A. By the aid of the microscope, which enabled them to discover the involved *stamen* * of

Wollaston's Religion of Nature, page 88. Fr. Medi. Exper. Nat. 81. de Gen. Insectarum. Ray's Wisdom of God, page 344. Clem. Phys. Part IV. chap. 2. § 33. et seq. More's Antidote against Atheism, Book 11. Chap. 6. Harris' Lexicon, at the word "Generation," and several other authors mentioned in Johnson's Philosoph. Quæst. p. 26, 27. and 33, 34.

* By the stamen is to be understood those rudiments, or simple original parts of a plant or animal, which first exist in the embryo, or fœtal state, or in the seed, and

the future plant in every single head, which is a very curious and delightful spectacle indeed. So that according to this doctrine, the first original seed of each kind (at the creation) contained in it all the future seeds and plants which were produced from it in all succeeding ages; and yet in itself was then no bigger than we see it now.

Q. Is it possible then, for instance, that one of our white boiling pease (capable of producing above an hundred fold yearly) should at the time of the creation, contain within its small globular bulk (about a quarter of an inch diameter) all that yearly product of pease, husks, stalks, of that kind ever since?

A. Matter, you must know, consists of parts

which afterwards by distinction and accretion of nutritious juices, extends itself to its utmost bulk; and then the plant or animal is said to be perfectly formed, or arrived to its mature state. This, in plants, is likewise called *germen* or *gem*, also *planticle*, or small plant; and may be seen in all seeds with the microscope, and in some with the naked eye, as the bean, and especially the kidney bean, where the very ribs of the leaves of the ensuing year's plant are visible in the seed of the preceding or existing year.

or corpuscules, inconceivably small; and to raise still higher the admiration, let us make the following calculation:—

Suppose then that one white pea will produce an hundred in the first year; then these will each produce an hundred more, and thus in all 10,000; these again in the third year would produce 1,000,000; in the fourth year, 10,000,000; in the fifth year, 100,000,000,000; and so on, increasing each year in a geometrical proportion, whose common ratio is 100; so that the product in any year will be expressed by a number consisting of a unit, with so many cyphers annexed, as are equal to twice the number expressing that year. Supposing therefore the age of the world were 5,673 years, then all the pease produced from that one pea to that time, would require a number consisting of 11,346 places of figures to express them; but the number of pease (reckoning fifty to a foot in length) which would be contained in a cube circumscribing the orb of the planet Saturn (which orb is 1,554,000,000 miles in diameter) would require no more than 44 places of figures to express: the quan-

tity then produced would equal such a number of these immense cubes, as would consist of 11,303 places of figures, which is considerably beyond all comparison and human comprehension—independent of the far greater quantity of stalks, cods, roots, leaves, &c.

Q. What kind of process does nature adopt to raise the plant from the seed in the ground?

A. The method of nature in this respect, as in all her other works, is most admirable, as will appear in the curious mechanism and construction of a bean root for instance (see fig. 1.) In which A. B. represents the two lobes of the bean slit, which are joined together by a little white sprig in O; in each lobe are seen the branches *aaa*, of that called the seed root *ee*, every where displayed through the body of the bean. These branches of the seed root *ee* feed the little sprout or earth root *oc* (descending downwards) with the pulp or matter of the bean (prepared by the ferment of the earth), till the said earth root is capable of penetrating the earth, and extending its parts sufficiently enough to extract, for itself and the plant it is to sustain, nourishment from

the juices and moisture of the earth; for from this earth root there springs upward the sprout F, called (by Dr. Grew) the *pluma,* or feather; and in this pluma and the earth root together is contained, in miniature, all the future plant. Thus it appears that the matter or substance of the bean serves much the same purpose to the seed root, as the yolk of an egg to the embryo chick; or as the earth does afterwards to the radule, or earth root itself, which has been enabled to shoot into the earth, in order to procure its own nourishment; after which, by means of the seed root, it is turned to the use of the pluma, causing it also to spring upwards, in order hereafter to become a trunk.

Q. What becomes of the seed lobes A B, when the earth root no longer requires their use?

A. In most seeds they are carried upwards with the pluma out of the earth, after which they compose the seed leaves, as they are called, as we see in cucumbers and French beans.

Q. Of what use are the seed leaves to the plant?

A. The uses and effects of these seed leaves

are, according to Malpighi, so necessary, that if they are pulled off, the plant will not grow; or if it should in any manner increase, it will not be complete, but always defective.

Q. In what manner does the root of the plant procure nourishment for its growth and increase?

A. In order to explain this, it will be necessary to shew the make and construction of the root, and as it were to anatomize the several parts appertaining to it, and then point out their uses: for this purpose choose two roots, viz. a root of wormwood (see fig. 2.), and a horse radish root (see fig. 3.), in each of which T represents the root cut transversely as it appears to the naked eye. The other great quadrantal figures are each a quarter of the aforesaid section T, magnified by a microscope; which thus enlarged, shews the various organical parts of which it is composed, and by which vegetation is performed.

Q. Have the goodness to describe the different appearances of those magnified sections.

A. 1. *A b* is the skin or rind, or outward membrane including the root.

2. From A to C in the *wormwood* root is the bark, which is a membranous substance, consisting partly of a great number of little bladders, or vesicles, B B B; the same as represented by *A B* in the horse-radish root. It also consists in part of a ligneous or woody substance, as from B to L in the root last named.

3. The wood of the root is all that part between B and E, in the horse-radish root; and from C C to the very centre in the wormwood root.

4. The wood of the root consists also of two different substances, viz. a ligneous one, properly the wood, as E E E, and a parenchymous one, like that of the bark, as D D D, inserted regularly between the portions of wood; these are very distinct in the wormwood root; but in the radish root, and in several others, they are not so visible.

5. In the wood you see the orifices of several tubes, or hollow veins, *a a a a*, which are the mouths of air-vessels.

6. From G to E, in the radish root, is ano-

ther little circle of vessels, like those of the bark.

7, and lastly, From E to the centre, in the radish root, is the pith, which consists of the same parenchymous *, or spongy substance of bladders, as doth the bark, and part of the wood; but the pith is not common to all roots, as, is seen, there is none in the wormwood root.

Q. What is the use of the several parts of the roots here described?

A. 1. The bladders in the bark render it a spongy substance, which therefore is fit to imbibe and suck up the watery parts of the soil, which are impregnated with the principles of vegetable life and growth. This impregnated water, imbibed by the bark, is what we call the

* The word parenchyma was formerly used to denote that red fleshy substance which lies between the interstices of the vessels in the bowels, and gives them their bulk; as in the liver, kidneys, spleen, &c., whence it was afterwards used to signify the soft, spongeous, or pulpy parts of any body, as of the leaves, roots, &c. of plants; and hence it is usual to say, such parts are *parenchymous*, that have such a matter and texture. *New. London Med. and Surg. Dict.*

sap; the skin of the root serving as a filtre, to strain and purify it on its first being absorbed.

2. The sap thus filtered and absorbed, ferments in the substance of the bark, by which process of nature it is further prepared, consequently more easily insinuates itself into the parenchymous substance of the root; on which, partly by the appulse of fresh *sap*, and partly by the pulsive motion of the extended bladder of the parenchyma, the sap is forced thence into the other parts of the root, and is still more and more strained in its passage from bladder to bladder.

3. The sap, thus distributed through the whole root, supplies its organical parts with those principles of nourishment which every one requires; and thus the root, by the constant application of those nutritious principles, receives its increment, solidity, and growth, or vegetative life and motion in every part.

Q. What is the use of the air-vessels, thus called?

A. These contain a proper kind of vegetable

air or vapour, which serves to ferment the sap entering into the ligneous part, the better to qualify it for assimilation, or uniting therewith.

Q. Why do the roots of some plants yield a milky juice or liquor, and others a clear watery one, when cut?

A. Because in each root, the fluid or liquor of each organical part is made chiefly by different filtrations of the sap through the sides thereof; consequently those which strain more freely the aqueous or watery part of the sap contain a lymph, or clear water; and hence are called lymphatics, or lymph-ducts; and where these are most numerous in roots, these roots, when cut, will bleed a lymph. The same as, on the other hand, those vessels which are disposed to admit the oily or balsamic part of the sap most copiously, are called *lactiferous vessels*; and roots which a great plenty of those will, when cut, give out a milky, oily, or balsamic fluid.

Q. The root thus formed, and invested with all its different organs of vegetation, what then is the next step which nature takes in the production of the plant?

A. The root having now become the procurator for the future plant, by extracting from the earth, through the medium of its vessels, proper vegetable juices and aliment, administers or communicates the same to the pluma, or seed plant (supported hitherto from the substance of the seed, by the seed root, or seed leaves), and thereby causes it to shoot forth vigorously and increase; and gradually to swell out or unfold all its blades, branches, buds, leaves, flowers, and seeds again, from various parts of its stalk or trunk.

Q. Apparently then, the same mechanism or apparatus of organized parts, is continued from the root to the trunk or stem of the plant, for the communication of this vegetable sustenance.

A. Yes; and in order to illustrate this, (see fig. 3) T represents one quarter of a section of a hazel branch, as it appears to the eye; A G B is the same as it appears through a good microscope; in which A B is the skin; A B C D the bark; Q Q Q the parenchyma of bladders, or sap-vessels; H I a ring of a special sort of vessels; P P common sap-vessels; C D E F

the ligneous substance, or wood, of three years growth; K L F E the wood of two years; M N E F the wood of the first year; X X the parenchymous insertions; O, the pith full of vesicles; the black parcels are the solid wood; the numerous holes appearing over the same are the mouths of air-vessels. Thus it is seen, that the organical constitution of the stalk, or trunk, is the same with that before shewn in the root:—a wondrous contrivance indeed, an analogy of the organization of the vegetables. The motion of the sap is as follows:—

1. The nutritious sap ascends the first year of a plant's growth by the vessels of the pith; after which the pith becomes dry, and so continues.

2. The next part, through which the sap rises, is the wood, by the air-vessels, and that only in the spring.

3. The third part, by which it ascends, is the bark, as already stated, the greatest part of the year; and this is the general theory of the motion of the sap *.

* Thus far the learned Dr. Grew, and others: but it is still a matter of great controversy how the sap ascends,

Q. But since both root and branch contain air-vessels, into what part of the plant does the air first enter?

A. The principal entrance of the air is at the root along with the sap; but it also enters more or less at the trunk, leaves, &c. parts of the plant. The air, or airy part of the sap, being thus raised in its proper vessels, is filtered through the same into the vesicles of the parenchymous insertions in the wood; and is thus distributed through all the parts of the plant or tree *.

and what course it takes after it is imbibed by the roots; whether it be by the bark, the pith or the wood, or all, as above-mentioned. The supporters of each hypothesis, and the arguments produced to support it, may be seen by consulting SHAW'S *Notes to Boerhaave's Chemistry*, p. 146, 147, &c. The circulation of the sap in trees is denied by Mr. Hales, in his Vegetable Statics, Vol. 1. Exper. 46, &c.

Boerhaave says (*see Theory of Chemistry, by Shaw*, p. 147), that since the sap is furnished by the earth, it will consist of some *fossile parts*, some parts delivered from the air and rain, and others from putrefied animals, plants, &c., and that therefore in vegetables are contained all kinds of salt, oil, water, earth, and probably all kinds of metal too, since their ashes always afford somewhat which the loadstone attracts.

* Hales has proved, by many curious experiments, that

Q. Why are the stalks of some plants hollow within?

A. Partly for the more expeditious ripening of the fruit or seed, which is better effected by a more plentiful supply of air by these hollow trunks; and partly for the better determining the true age of the plant; for the air in this hollow, by drying up the sap, contracts the sap-vessels so much as to prevent the circulation of the sap in them; whence the plant must of course perish: hence the reason why the greater part of annual trunks are hollow.

Q. Whence proceeds the form or figuration of the trunks of plants and trees?

A. Chiefly from the air in the air-vessels: for instance, almost all shrubs have a greater number of air-vessels, and those of a smaller size, which, consequently, yielding more readily to the magnetic attraction of the external air, spread most abroad, by which the air-vessels

all plants perspire in a considerable degree, but *evergreens* the least of any. He discovered that the quantity of nourishment, imbibed and perspired in a sun-flower, is to that of a man, bulk for bulk, as 17 to 1. *See Veget. Statics, Exp.* 1.

sooner, and with more facility, shoot into the bark, and so produce collateral buds and branches, and that upon the first ruins of the plant from the root, hence it becomes a shrub. But if the air-vessels be very large, as in the oak, walnut, elm, &c. they will not so easily yield or shoot out collaterally; and so the trunk grows up taller and more entire.

Q. Why do some trees run up so very slender, and others so very thick and big?

A. These variations of growth is a consequence of the position of the air-vessels; for where these lie most circular round the centre in the form of rings, as in elm and ash, there the tree in proportion grows more tall and taper, and less thick. But when these air-vessels spread more broad, and are postured in line from the centre, as in the oak, &c., then the tree grows very thick; in this the diametrical growth of the wood is more promoted than in any other; for which general reason, also, trees grow round or angular.

Q. How comes it to pass, that several stalks of plants have joints or knots? And what is their use?

A. Because in forming the branch or blade, both the rind and woody substance of it are, in their shooting forth, devacuated from their perpendicular posture to a cross position; and as they, with the other, grow and thrive together, they bind and crowd each other into a knot.

Q. How is the *production* and *texture* of leaves accounted for?

A. The parts of the leaf are substantially the same with those of the branch; its skin is the continuation of that branch; the fibres or nerves, dispersed through the leaf, are only ramifications of the branch wood, or ligneous body: the parenchymous substance, which lies between the fibres, is nothing but the continuation of the cortical body, or substance of the bark, spread through the same.

Of the different distinctions of leaves, according to their position and form, above an hundred are enumerated. (See observations on the fall of the leaf.)

Q. What is the use of leaves?

A. 1. For protection, which they afford to

each other, and to the flower in the bud; as also to the fruit itself in some parts.

2. For augmentation—for the capacity of the due spreading and ampliation of a tree or plant, are its leaves.

3. The leaves, which may comparatively be termed the digestive organs of plants, serve to purify and prepare the sap, the grosser parts of which are retained in the leaves, while the more elaborate and essential are supplied to the flower, fruit and seed, as their proper aliment.

4. They serve for promoting the functions of perspiration; as the orifices observed in leaves perform the same function in trees, as the pores of the body do in animals—namely, they cause an insensible or invisible perspiration in plants*. (See fall of the leaf.)

* It is difficult, notwithstanding the great perspiration in animals and plants, to discover any thing like pores in the scarf-skin of the one, or the fine membranes which cover the leaves of the other; even with the best sort of double reflecting microscopes. Mr. Lowenhoek (*Trans. Philos. No.* 369.) tells us, however, that he has viewed these pores or spiracles very clearly in the leaves of box; and that in one superficies of such a leaf, he has computed 172,090 pores, and in the other as many. The Royal

Obs. The leaves of plants (such as have woody fibres) are easily anatomized, and a skeleton of the fibres made, in the following manner:—

a. The leaves must be gathered when full grown, or old, but not dry. They are then to be exposed in an open vessel of water, and as fast as it evaporates filled up again.

b. After the expiration of a month or two the leaves will begin to putrify, or grow soft; and the pellicle or thin skin on each side, will first begin to separate from the pulpous part of the leaves.

c. The leaf is now to be put into a broad pan

Society received and admitted this for truth, "whence," says Benj. Martin, (*See Philosoph. Grammar*, *p.* 276.) "I believe it may be easily made to appear that nothing is more false; and that, instead of seeing 344,180 pores, he never saw one." There is, however, something exceeding fine and delicate in the texture of the pellicle or fine membrane which covers the box leaf, and also in the skeleton made thereof; also that the transparent sphericles, or round clear drops, standing well over the surface of the leaves of hyssop, mint, &c., and others of forms and colours in other plants, make a very pleasant and delightful view in the microscope.

of water, where there is room to squeeze the pulpous or green substance of the leaf, which must be done very gently; and it will easily separate from it, and leave an entire skeleton of fibres.

d. Or the leaf, stript of its skins or membranes, may be laid on a piece of paper, where after it has lain a little to dry, take hold of the tail of the leaf, and gently raising it, the skeleton has separated freely from the pulp, which adheres to the paper*.

e. In many of these skeletons, as that of the apple-tree, cherry-tree, holm, &c., you will find that all the fibres, great and small, are double; or that there are two layers or planes of fibres, which, it may be observed, will easily detach from each other through the whole skeleton.

f. These two planes of woody fibres, which compose the skeleton of a leaf, are supposed to be analogous to the arteries and veins of an animal body. But there is no discerning which are the arterial, and which the venal fibres. (See the

* *See Herbarium.*

figure of the skeleton, and its duplicature, of an apple-leaf, fig. 4.)

g. In the same manner may fruits be prepared, and skeletons of them be procured, as apples, pears, peaches, &c. They must be sound and good, pared very nicely, then boiled gently till they are thoroughly soft; then taking them out, and putting them into a bason of cold water, hold the tail in one hand, and with one finger and thumb of the other, rub the pulp gently off, and preserve the skeleton in rectified spirit of wine.

h. Carrots, and other roots that have woody fibres, must be boiled without paring till they grow soft, and the pulp comes off. Not only many sorts of roots, but the bark of several trees also, may be reduced after this method into skeletons, presenting rare and curious views of vegetables. *Philosoph. Trans. No.* 414. *and* 416.

CHAPTER II.

ON THE FLOWERS OF PLANTS, &c.

Q. What is there particularly to be observed relative to the flowers of plants?

A. In the flower may be observed—

1. The empalement, calyx, or cup, which contains the flower, and is designed for the guard and security of the other parts of the flower.

2. The foliation or composure of the leaves, which is of various forms and colours; whose constituent parts are the same as those of the leaves, viz., skin, parenchyma, air, and sap-vessels.

3. Within the *foliage* stands the *attire*; namely, those fine upright *stems*, with their *apices*, and the *style* in the very middle of all; and these are the general parts of which the flower consists.

Q. What are the uses of those several parts of the flower?

A. The *empalement*, as already observed, is for the security of the flower in embryo, and afterwards for the support of the foliage, to keep the leaves of the flower in due and decorous posture, which would otherwise hang in an unseemly and tawdry manner. The *foliage*, or leaves of the flower, defend the *attire*, and in some plants the fruit; it also serves for the further refining and separation of proper parts of the *sap*, for bringing the seeds to perfection. The *attire* is an ornament and distinction in flowers. It also supplies various small insects with food which harbour in it, that is, in the hollow of the style. Lastly, it is supposed that it likewise serves as male sperm, to impregnate and fructify the seed.

SEXUAL DISTINCTIONS OF PLANTS.

1. That there is a sexual distinction in plants, that some are male, others female, and most hermaphrodite; and that the flower is the pudendum of the plant, as containing the parts of generation, are points agreed upon among modern naturalists.

2. The male parts of a flower are the *stamina* or stem, and their *apices* or little tops, which contain the fine powder, or *farina,* which is supposed to be the *semen,* or seed of the plant.

3. The female parts are the *style,* which serves to receive the *semen;* and the *seed-case* at the bottom of the *style,* which is imagined to be the matrix, or womb of the plant.

4. Some plants have only the male parts of the flower, and they never bear fruit; others the female parts only, and they bear fruit. In others, as *cucumbers, melons, gourds, walnuts, oak, beech,* &c. the male and female flowers grow at some distance from each other.

5. But most plants are hermaphrodites, or have the male and female parts in the same flower, as the *pulp, lily, polyanthus,* &c.

6. The manner in which plants are impregnated and generated is not clearly understood, although it is generally agreed that the *farina,* falling upon the *apicis,* is received by the *style,* or pistæ, which conveys it to the *seed-case* below, where it impregnates the embryo seed contained therein. Much has been said for and against this

hypothesis; a short view of which controversy may be seen in Shaw's notes to Boerhaave's chemistry, as well as in other botanical authors.

CHAPTER III.

ON THE FRUIT OF PLANTS, &c.

Q. What is the nature and composition of fruit?

A. The general nature and composition of fruit is one and the same; that is, their essential and truly vital parts are in all the same, and only the continuation of those which, as already observed, constitute the other parts of the plant. But from the different constitution and textures of these parts many considerably different fruits result, as apples, pears, plums, nuts, berries, &c.

Q. What are the particular parts which compose those different structures?

A. 1. The *apple* consists of the following four parts, viz. the *pilling*, the *parenchyma* or *pulp*, *branchery*, and *core*.

2. The *pear* has five distinct parts, viz. the *pilling*, the *parenchyma*, the *branchery*, *calculary*, and *acetary*.

3. The *plum* (to which the cherry, apricot, peach, &c. may be referred) consists of four parts, viz. the *pilling*, *parenchyma*, *branchery*, and *stone*.

4. The *berry* consists of four parts, viz. the *pilling*, *parenchyma*, *branchery*, and *seed*.

5. The *nut* consists of three parts, the *cap*, the *shell*, and *pith*. (See *pith*, p. 67.)

Q. What are the principal uses of fruits ?

A. The use of fruit is two-fold : 1st, It serves man as well as beast, as a delicious and pleasant meat or food, besides the various purposes of medicine ; 2d, It supplies the seed with a due and most convenient *sap* ; the fruit doing the same office to the seed as the leaves do to the fruit, viz. that by a due purification and exaltation of the sap, the seed may arrive at perfection.

Q. What is the seed in its state of generation?

A. As the original, so the ultimate end and perfection of vegetation, is the seed. The manner

in which in its state it has been adapted to vegetables is already explained. Its state of generation is as follows: The sap, in the root, trunk, and leaves, having passed divers concoctions and separations, is at last in some good state of maturity advanced towards the seed. In the fruit, as was said, it is still farther prepared, and the more essential part is transmitted into that particular part of the branchery, called the *seed-branch;* which, because it is a good length, and very fine, still farther maturates the sap in passing through it: in this mature state, it is conducted through the *seed-branch* into the coats of the seed, as into the womb. The meaner part of the sap to the outer coat, the more fine is transmitted to the inner coat, where it is farther prepared by fermentation; and thence it is filtered through a fine skin into the innermost part or substance of the seed, where it becomes a liquor fit for actuating the future embryo seed, that is, causing it to vegetate, and the plume to shoot forth.

CHAPTER IV.

MOSS, MUSHROOMS, AND OTHER FUNGOUS EXCRESCENCES, ADHERING TO THE SIDES OF TREES.

Mushrooms, moss, and other fungous excrescences, are a spurious kind of plants, or rather excrementitious plants, since they entirely arise from the bodies of other plants, or from a kind of viscous mucilage of the earth. They indeed grow, and have roots, some inserted into the fibres of the plant producing them, e. g. misletoe is radicated into the fibres of the oak; and moss to the fibres of the barks of trees; mushrooms arise from various matters in earth and wood, and are found to consist of a vast bundle of fibres, proceeding from the substance on which they grow, and which forms the stalk; thence devaricating, spread and extend themselves into a spherical canopy or head, which contains a succulent parenchyma; on the under part of which, it is probable, the seed is produced,

though none hitherto has been seen, which, being wafted about by the wind, falls in divers places of the earth, and there takes root and grows: thus moss undoubtedly bears seed, by which the various sorts of it are propagated, though, on account of their smallness, they cannot be seen.

a. Of moss, naturalists make mention of about 300 different kinds; though those which grow common are not above 50 in number. They have a great variety in their growth, form, and make; and most of them form an agreeable sight in the microscope. In consequence of nothing like flower seeds being found in many of them, they are truly judged to be plants of their own kind.

b. Dr. Lister takes the gills of mushrooms to be the very flower and seed of the plant; indeed no other can be detected by the microscope. The mouldiness on leather, paste, pickles, &c. is of the mushroom tribe; they are well known to be of a speedy growth, and consist of a multitude of fine stalks and stones; on the tops of which grow round heads, containing a kind of liquor, which may be found by bruising them under the microscope.

c. The *fungi*, or what we call *Jew's-ear*, *Agaric*, *&c.*, which grow on the rind of trees, are of a very porous substance. If the superficies of some be viewed with a microscope, they will appear like a honey-comb, full of holes, which go deep, and make a fistular substance. In these, there is still less discernible of roots, flower, or seed.

d. The puff-balls are another sort of odd production; these at first have a fleshy substance, pretty firm, which, by degrees, becoming more ripe, change to a kind of dust, which Mr. Bradley supposed to be the seed.

e. The truffle, like the puff-ball, is formed under ground, it lies about six or eight inches deep; is of a firm and fleshy substance within, and cortical without. The fleshy part, if viewed in their slices under the microscope, appears to be composed of roundish, opake, and very small particles, thickly interspersed through a white, transparent, and seemingly vascular substance, which runs in larger and finer veins all over the substance of the truffle. They are of two kinds, one round, the other of an egg-like figure. They are of a strong and very disagreeable

odour; but esteemed in food as a very delicious and luxurious piece of dainty. They are found very common in the woods of Italy and France; and latterly in different parts of England. And dogs are there taught to hunt them out with as great sagacity, and as easily as to set game.

f. As regards *submarine* vegetables, namely, as those which grow in and under the sea, as the large green membranous sea-belts, which grow on stones; the fuci and other sea-weeds; the coralines on stones and oyster-shells; the sea fan; the coral, which grows on rocks; the sponge, &c., they are so numerous and various, as not to admit to be treated of in this place, further than to observe, that they in general appear to be deficient in roots, flowers, and seeds; and are most of them of a very wonderful texture and make; especially the sponge, which has a very fine effect seen through the microscope.

POISONOUS MUSHROOMS.

Among the numerous species of fungous plants, none are so decidedly poisonous as the

pepper agaric, the deadly agaric, champignon, and some others.

The symptoms they occasion are nausea, heat and pain in the bowels, with vomiting and purging; thirst, convulsions, faintings; small and frequent pulse; delirium, dilated pupil, and stupor; cold sweats, and often death.

The treatment, under these circumstances consists in clearing out the stomach and bowels by means of an emetic of tartarized antimony, followed by frequent doses of Glauber or Epsom salts, and large stimulating glysters. After the evacuation of the poisonous substances æther may be administered, with small quantities of brandy and water; but should inflammatory symptoms present themselves, such stimuli should be omitted, and other appropriate means, as bleeding, and the antiphlogistic regimen, put in practice. (*See New London Medical Pocket Book*, p. 247.)

TO DISTINGUISH POISONOUS FROM EDIBLE MUSHROOMS.

The poisonous fungi may be distinguished from such as are eatable by their botanical characters, and the following simple indications; viz., the former, or poisonous mushrooms, grow in wet shady places, have a nauseous odour, are softer, more open and porous; with a dirty looking surface, sometimes a gaudy colour, or many very distinct hues, particularly if they have been covered with an envelope; they have soft bulbous stalks, grow rapidly, and corrupt very quickly.

POISONOUS PLANTS.

Among the principal of this class of poisons may be enumerated.—

1. Blue monkshood.	5. Fool's parsley.
2. Bane berries.	6. Fox-glove.
3. Deadly night-shade.	7. Long leaved water hemlock*.
4. Bear's foot.	

* Persons not conversant in practical botany are very apt to confound this plant with what is called the *phellandrum aquaticum*, called also water-hemlock, an instance

8. Thorn apple.	13. Garden night-shade.
9. Henbane.	14. Woody night-shade.
10. Dog's mercury.	15. Mezereon.
11. Hemlock dropwort.	16. Meadow saffron.
12. Laurel.	17. Wall-pepper, &c*.

Obs. All plants, whose flowers have five *stamens*, one *pistil*, one *petal*, and whose *fruit* is of the *berry* kind, may at once be pronounced as poisonous; the *umbelliferous* plants which *grow in water* are mostly poisonous; and such as have the *corolla* purple and yellow, may be suspected of being so.

CHAPTER IV.

OF THE CLASSIFICATION OF PLANTS.

The botanical systematic arrangement of Linnæus contains, in a compendious manner, a view of the whole vegetable kingdom, disposed

of which occurs in Mr. Wilmer's Pamphlet on Poisonous Vegetables, published in 1781, when Captain Donellan's trial was so generally the subject of conversation.

* Many of these are irritating, others narcotic poisons, that is, some act through the medium of the circulation,

according to the order of which he was the inventor, and is founded, as regards its classification, upon the sexes of plants. A system which is now almost universally received, and which has gained its author immortal honours. It is in this branch of the study of nature that the illustrious Swede so eminently shines; from him it is that botany justly boasts a new era, and without derogating from the merit of former writers, it may truly be said, that it never really was reduced to a science before.

It is almost needless in the present state of knowledge to urge the necessity of a method in the study of nature; it is the very soul of science, and amidst such a multiplicity of objects as the vegetable kingdom affords, all attempts towards the acquisition of knowledge without it, must end in uncertainty and confusion. Of this there are sufficient proofs among the writers on plants before the invention of systems; and we see and deplore the want of it in the loss of

others through that of the brain and nerves. For the several symptoms and treatment, see *New London Medical Pocket Book*, p. 244., for an excellent, well connected and condensed view of this subject.

many valuable articles, not in the *Materia Medica*, but in the *Pictoria* and *Tinctoria* of the ancients.

Q. How many classes are there in the Linnæan system; and on what are the characters of these classes founded?

A. Twenty-four; the characters of which are taken from the number, connexion, length and situation of the stamens.

Q. How are these classes distinguished?

A. There are stamens and pistils in the same flower, in each of the first twenty classes; in the twenty-first class they are in distinct flowers on the same plant; in the twenty-second, in distinct flowers on different plants; in the twenty-third they are in the same flower as well as in distinct ones; and in the twenty-fourth class they are not all to be seen.

CLASSES.

The names of the classes are founded on Greek words, which express their respective characteristics. The first ten are named from the Greek numerals, and the word *andria*, which must be considered as equivalent to *stamens*.

These are as follow:—

1. MONANDRIA,	having	One stamen.
2. DIANDRIA,	——	Two stamens.
3. TRIANDRIA,	——	Three stamens.
4. TETRANDRIA,	——	Four stamens.
5. PENTANDRIA,	——	Five stamens.
6. HEXANDRIA,	——	Six stamens.
7. HEPTANDRIA,	——	Seven stamens.
8. OCTANDRIA,	——	Eight stamens.
9. ENNEANDRIA,	——	Nine stamens.
10. DECANDRIA,	——	Ten stamens.
11. DODECANDRIA,	——	Twelve stamens.
12. ICOSANDRIA,	——	Twenty stamens.
13. POLYANDRIA,	——	Many stamens.
14. DIDYNAMIA,	——	Four stamens, two longer.
15. TETRADYNAMIA	——	Six stamens, four longer.
16. MONADELPHIA,	——	Filaments united at bottom, but separated at top.
17. DIADELPHIA,	——	Filaments in two sets.
18. POLYADELPHIA,	——	Filaments in many sets.

19. SYNGENESIA, having Stamens united by antheræ.

20. GYNANDRIA, ——— Stamens and pistils together.

21. MONŒAU, ——— Stamens and pistils in separate flowers upon the same plant.

22. DIŒCIA, ——— Stamens and pistils distinct, upon different plants.

23. POLYAMIA, ——— Variously situated

24. CRYPTOGAMIA, ——— Flowers invisible.

DISTINCTION OF THE CLASSES.

a. All plants having but one stamen are of the first class; those that have only two are of the second; those that have only three are of the third, and so on; the number of stamens being the same with the number of the class in the first ten classes.

b. The eleventh class (Dodecandria) contains all such plants as have from twelve to nineteen stamens fixed in the receptacle.

c. The twelfth class (Icosandria) is known by

having twenty or more stamens, fixed to the inside of the calyx. In this class the place of insertion is more to be relied on than the numbers of the stamens, for there are sometimes less than twenty and sometimes more.

d. The plants comprehended in the thirteenth class (Polyandria) are those that have more than twenty stamens attached to their receptacle.

e. The fourteenth class (Didynamia) are distinguished by four stamens in a flower, of which two are longer than the others.

f. The fifteenth class (Tetradynamia) is known by having six stamens in the flower, four of which are longer than the other two.

g. In the sixteenth class (Monadelphia) the stamens are united by their filaments into one set, forming a case round the lower part of the pistils, but separating at the top.

h. In the seventeenth class (Diadelphia), the corolla are paplionaceous (like a butterfly) as the blossom of a pea; the stamens are connected by their filaments, but divided into two sets, one of which is thicker, and forms a case round the pistil; the other is smaller, and leans towards the pistil.

i. In the eighteenth class (Polydelphia) the stamens are united by their filaments into more than two sets or parcels.

k. The nineteenth class (Syngenesia) consists of compound flowers, as the common daisy or dandelion; and they are called compound, because each single flower consists of a collection of little flowers or flowerets, attached to the same broad receptacle, and contained within one calyx.

l. In the twentieth class (Gynandria) the stamens are attached to the pistil.

m. The twenty-first class (Monœcia) is known by containing those plants which have flowers of different kinds on the same plant, some bearing pistils, and others stamens only.

n. The twenty-second class (Diœcia) consists of those species which have stamens on one plant, and pistils in another.

o. The twenty-third class (Polygamia) embraces those plants which have at least two, and sometimes three kinds of flowers:—

1. Some with pistils and stamens in the same flower.

2. Others having stamens only.

3. Or having flowers with three pistils only.

p. In the twenty-fourth class (Cryptogamia) are comprehended all plants in which the flowers are invisible to the naked eye, e. g. mosses, ferns, mushrooms, sea-weeds, &c.

CHAPTER V.

ORDERS OF PLANTS.

The orders of plants are as ingeniously and simply formed as the classes.

In the first thirteen classes, the orders are founded wholly on the number of the pistils; so that by adding *gynia* instead of *andria*, to the Greek words which signify the numbers, they will be easily recollected. Where they are not distinguished by the number of the pistils, their names are derived from some circumstance relative to the stamens, pistils, or seed.

The first thirteen orders are :—

1. Monogynia, having One pistil.

2. Digynia,	having	Two pistils.
3. Trigynia,	———	Three pistils.
4. Tetragynia,	———	Four pistils.
5. Pentagynia,	———	Five pistils.
6. Hexagynia,	———	Six pistils.
7. Heptagynia,	———	Seven pistils.
8. Octagynia,	———	Eight pistils.
9. Enneagynia,	———	Nine pistils.
10. Decagynia,	———	Ten pistils.
11. Dodecagynia,	———	Twelve pistils.
12. Icosagynia,	———	Twenty pistils.
13. Polygynia,	———	Many pistils.

Q. In the fourteenth class, how many orders are there, and how are they known?

A. In this class there are only two orders, which depend on the presence or absence of the pencarp or seed-vessel:—

a. Gymnospermia. Naked seeds in the bottom of the calx, e. g. mint, dead nettle, thyme, &c.

b. Angoispermia. Seeds enclosed in a pencarp; as in fox-glove, eye-bright, figwort, wood-flax, &c.

In the fifteenth class (Tetradynamia) there are two orders, taken from a difference in the pericarp.

a. Siliculosa. Seeds enclosed in a silicle, or roundish seed-vessel, consisting of two pieces, called valves, and the seeds fixed to both edges, or sutures; e. g. cress and shepherd's purse.

b. Siliquosa. Seeds enclosed in a silique, or long seed-vessel; as in mustard.

Q. How do you distinguish the orders of the next three classes?

A. In the classes *Monadelphia, Diadelphia,* and *Polyadelphia,* the orders are distinguished by the number of stamens, namely, *Pentandria,* five stamens; *Hexandria,* six stamens.

Q. In the nineteenth class (Syngenesia), how many orders are there?

A. Six orders, which derive their name from the structure of the flower:—

1. *Polygamia æqualis,* having both stamens and pistils in the same floweret, e. g. thistle, dandelion, &c.

2. *Polygamia superflua,* when the flower is com-

posed of two parts—a disk or central part, and rays or petals projecting outwards, as in sunflower, tansy, daisy, camomile, &c.

3. *Polygamia frustranea,* the flowerets of the centre, perfect or united; those of the margin, without either stamens or pistils, as blue-bottles.

4. *Polygamia necessaria,* where the flowerets in the disk, though apparently perfect, are not really so, and therefore produce no perfect seed; but the fertility of the *pistilliferous floscules* in the ray, compensate for the deficiency of those in the centre of the flower, as in the marygold.

5. *Polygamia degregata,* when each of the flowerets has a calyx, besides the common, or general calx of the flower.

6. *Monogamia,* when the flower is not compound but single, and the anther united.

The orders formed in the next three classes (grandria, monœcia, and diœcia), are from the number and other peculiarities of the stamens, e. g.—

MONANDRIA, having one stamen.

DIANDRIA, —— two stamens, &c.

POLYANDRIA, —— seven stamens.

MONADELPHIA, stamens united into one set.
POLYDELPHIA, stamens united into different sets.
GYNANDRIA, stamens upon the pistil.

In the twenty-third class (Polyamia) are comprised three orders, viz. *monœcia, diœcia,* and *triœcia.*

In the twenty-fourth order (Cryptogamia) are four orders, namely, ferns, mosses, sea-weeds, and funguses.

CHAPTER VI.

CLASS I. MONANDRIA. (One Stamen.) TWO ORDERS.

Ex. Most of the plants belonging to this order are natives of India, as ginger, cardamoms, arrow root, turmeric, &c.; but we have the *hippuris* (mare's tail), which grows in muddy pools and ditches; and as it is not difficult to be procured, it may serve for an example of the first order.

Description of the Hippuris, or Mare's tail.—It has neither calx nor corolla. A single pistil denotes its order, and it has only one stamen,

which grows upon the receptacle, terminated by another slightly divided, behind which is the pistil, with an awl-shaped stigma, tapering to a point. The stem is straight and pointed, and the leaves grow round the joints; at the base of each leaf is a flower, and it is seen in bloom in the month of May.

The *star-wort* belongs to the second order of this class, and takes its name from the upper leaves making a star-shaped appearance. It contains two pistils, and is to be met with in ditches and standing water; and may be seen in blossom at any time between April and October.

Class II. Diandria. (Two Stamens.)

THREE ORDERS.

Ex. The privet *(sigustrum)*, a shrub very common in our hedges. It bears a white blossom, and generally flowers in June, having a very small tubulated calx of one leaf, with its rim divided into four parts. The blossom is also funnel-shaped, with an expanded border, cut into four ovate or egg-shaped segments. It is known to belong to this class by having two

stamens placed opposite to each other, and nearly as long as the blossom. *The seed* is roundish, the pistil or style short, terminated by a thick blunt stigma. *The leaves* grow in pairs, and are sometimes variegated with white or yellow stripes. It bears berries. The seed-vessel is a black berry, containing only one cell, which incloses four seeds.

Obs. The berries of the privet are used in dyeing, from their giving a durable green colour to silk or wool, by the addition of alum.

The common jessamine *(jassminum officinale)*, a native of India, but long cultivated in Europe, also belongs to the class diandria. It is an ornamental shrub, chiefly reared against walls, and is interesting not only from the elegance of its foliage, but also from the number of beautiful white flowers with which it is adorned, that exhale a grateful odour, particularly after rain, and during the night. Also several useful spices, as pepper, of which there are upwards of sixty different species, all natives of the East and West Indies.

Class III. Triandria. (Three Stamens.)

THREE ORDERS.

To this class belong various grasses, every single blade of which bears a distinct flower, perfect in all its parts, which, when accurately observed, cannot fail to excite our admiration. *The general character of grasses,* of which there are upwards of three hundred species, may be described as follow: The leaves furnish pasturage for cattle; the smaller seeds serve as food for birds, and the larger for man; some, however, are preferred to others, as *fescue,* for sheep; *meadow grass,* for cows; *canary,* for small birds; *oats* and *beans,* for horses; *rye, wheat* and *barley,* for man. They also furnish us with our most important articles of food and clothing, as bread, meat, beer, milk, butter, cheese, leather, wool, &c.; and all the advantages resulting from the use of cattle would be lost without them.

Grasses are distinguished from other plants by their simple, straight, embranched stalk, hollow jointed, commonly called a straw, with long, narrow, tapering leaves, placed at each knot

or joint of the stalk, and sheathing it by way of support. Their ears or heads consist of a husk, composed generally of two valves, which form the calx; inclosed in which is the blossom, being also a husk of two valves. The sugar cane, as well as the celebrated plant called by the ancients *papyrus,* belong also to this class *.

Obs. Linnæus has arranged grasses into four divisions. The first three include those which are produced in panicles or loose branches, distinguished by the number of flowers in each empalement: the *first,* having one flower; the *second,* two; the *third,* several. The fourth division consists of all those that grow in spikes or heads, as wheat, rye, barley, &c.

Class IV. Tetandria. (Four Stamens.)

THREE ORDERS.

Ex. Teasel *(dipsacus fullonum),* madder, ladies' bed-straw, holly *(ilex aquifolium),* &c.

* *Papyrus,* the ancient paper, the inner bark of which the ancients used to write upon. Some books are said to be composed of leaves. *Volumen* was the manuscript rolled up. Hence our words library and volume, from the word *liber,* signifying the inner bark of a tree.

Obs. Teasel is distinguished from other plants of the same tribe, by having its leaves connected at the base, the flower scales hooked, and the general calx reflected or bent back.

Class V. Pentandria. (Five Stamens.)

SEVEN ORDERS.

This class, which comprises one-tenth of the vegetable world, includes many very agreeable flowers, as well as noxious plants. The primrose, oxlip, passion flower, polyanthus, &c. belong to this class, as well as a tribe of plants called luridæ, which are distinguished not only by having the characteristic marks of five stamens and one pointal, but they coincide in a calx that is permanent and divided, like corolla, which consist of one petal, into five segments. Their seed is either a capsule or a berry, inclosed within the flower, e. g. the deadly night-shade, *(atropa belladonna)*; the thorn apple, *(datura)*; henbane, *(hyoscyamus)*; the night-shade, *(solanum)*; which comprises two kinds, namely, the woody night-shade, known by its blue blossoms and red berries; the garden night-shade, distinguished by its white blossom and black berries.

Class VI. Hexandria. (Six Stamens.)

SIX ORDERS.

Ex. The tulip, the hyacinth, lilies of every kind, the amaryllis, the great American aloe, and many other exotic plants of the libaceous tribe belong to this class; also the snow-drop, *(galanthus nivalis)*, barberry, daffodil, narcissus, &c.

Class VII. Heptandria. (Seven Stamens.)

FOUR ORDERS.

Ex. The horse-chesnut *(æsculus hippocustanum)*, in botanical characters, are a small calx of one leaf, slightly divided at the top into five segments, and swelling at the base; a corolla of five petals, inserted into the calx, and a capsule of three cells, in one or two of which only is a seed. For an interesting account of chesnut-trees, *see Phillip's Pomanum Britannicum.*

Class VIII. Octandria. (Eight Stamens.)

FOUR ORDERS.

Ex. Various shrubs, native and foreign; among

the first may be included the common maple and sycamore trees, and the cranberry and whortleberry shrubs, with the common heath, which grows wild on mountainous wastes in almost every part of England. Among the foreign ones are the balm of Gilead shrub, which grows in several parts of Abyssinia and Syria; the sugar maple of North America, which is 50 or 60 feet high; and the rosewood tree, in the island of Jamaica, &c.

Class IX. Enneandria. (Nine Stamens.)

THREE ORDERS.

Ex. Several foreign plants, as cinnamon, cassia, sassafras, bay, camphor, and rhubarb. The only plant belonging to this class in this country is the flowering rush *(butomus umbellatus)*, which grows in the water, having a round smooth stalk, rising from one to six feet in height, according to its situation; at the top of which is a head of bright red flowers, sometimes not less than thirty; three short leaves form the cup, and the corolla has six petals. This plant is so hardy as to defy the severest frost.

Class X. Decandria. (Ten Stamens.)

THREE ORDERS.

Ex. In this class are comprised several trees of foreign growth, as well as various plants and flowers common to this country. The lignum vitæ, logwood and mahogany, all natives of the West Indies, all belong to this class. The carnation, the sweet William, and whole tribe of pinks; also the fly-trap of Venus, a native of America.

Q. Describe the fly-trap of Venus.

A. At the bottom of the footstalk of this singular plant are several leaves, each of which are divided into two lobes at the extremity, having long teeth on the margin, like the antennæ or feelers of insects, and armed within with six spines; these lie spread upon the ground round the stem, and are so irritable, that when a fly happens to light upon a leaf, it immediately folds up and crushes it to death.

Obs. Dr. Darwin observes, that he "saw this plant in the collection of Sir B. Boothby, of Ashbourn-hall, Derbyshire (1788), and that on

drawing a string along the middle of the rib of the leaves as they lay upon the ground round the stem, each of them in about a second of time closed and doubled up, crossing the thorns over the opposite edge of the leaf, like the teeth of a spring rat trap."

Class XI. Dodecandria *. (Twelve Stamens.)

SIX ORDERS.

Ex. Weld, or dyer's weed, which is found on barren ground, or on walls. In the clothing counties of England it is cultivated to a great extent, for the purpose of dyeing, as it affords a most beautiful yellow for cotton, woollen, silk or linen, which is procured from its roots and stems; and blue cloths dipped in a decoction of it turns green. The yellow hue of the paint, called Dutch pink, is also obtained from this plant. Its leaves are open-shaped and entire, with a dentiform or toothlike process on each side of the base. The flowers are yellow, and

* Although the word *Dodecandria,* implies twelve stamens, yet this class includes plants, as have from twelve to nineteen.

in long spikes; and the calx is divided into four segments.

CLASS XII. ICOSANDRIA. (Twenty Stamens.)
THREE ORDERS.

Ex. A great variety of fruit trees, such as the apple, pear, cherry, plum, nectarine, peach, almond, and medlar. Also various shrubs and herbs; such as laurels, roses, strawberries, &c.

CLASS XIII. POLYANDRIA. (Stamens numerous and indefinite.) SEVEN ORDERS.

Ex. The poppy and tea-tree.

CLASS XIV. DIDYNAMIA. (Four Stamens, two long and two short.) TWO ORDERS.

Ex. The plants comprehended in this class are for the most part garden herbs, and valued for their odoriferous smell and kitchen uses, as well as for the medicinal qualities which some of them possess: of the first order, may be included, common spearmint *(mentha vividis)*, dead-nettle, thyme: of the second, foxglove, wood flax, eye-bright, figwort.

Class XV. Tetradynamia. (Six Stamens, four long and two short.) two orders.

Ex. The plants of this class are all eatable, and generally supposed to possess anti-scorbutic properties; as the cabbage, turnip, the water cress, and mustard, with a variety of wild plants and flowers. Shepherd's purse and cress belong to the first order; mustard to the second.

Class XVI. Monodelphia. (All the Filaments united at the bottom, but separate at the top.) eight orders.

Ex. The cotton plant, cultivated in the East and West Indies, and other hot countries.

Class XVII. Diadelphia. (Filaments united in two sets.) four orders.

Ex. Of this class are many plants known to us, as beans, peas, vetches, clover, lucern, broom, furze; these are called paplionaceous, that is, having the leaves butterfly-shaped.

The curious sensitive plant called *Sensitive Heydasarum,* a native of Bengal, and which may

be considered as one of the most extraordinary plants in the vegetable kingdom, belongs to this class. When the air is quite warm and very still, its leaves are in continual motion, some rising, others falling, and others turning round by twisting their stems. The cause of these phenomena are by no means accounted for, though Dr. Darwin conjectures that this spontaneous motion of the sensitive plant may be as necessary as respiration to animal life. It grows about three feet high; the leaves are of a bright green; and the flowers of a pale red, slightly tinged with blue or yellow.

Class XVIII. Polyadelphia. (Filaments united, making many sets.) three orders.

Ex. Several foreign fruit trees, as the orange, the lemon, the citron, and the cocoa-nut trees.

In Bowdler's poetical introduction to Botany, are the following beautiful lines, so beautifully descriptive of the citron, lemon and orange, that we cannot resist the pleasure of introducing them to our readers.

"In beauty blooming, and in artless grace,
The fragrant *citron* rears her glittering race;
The pale-eyed lemon, lofty and austere,
Checks her gay suitors with a tone severe;
With milder charms along the fertile glade,
Glows bright *Amantia* with a deeper shade;
Rears her tall head in vegetable pride,
And bends her loaded boughs on every side;
These juicy stores to foreign skies unfold,
In clusters thick, like pendent drops of gold.

Class XIX. Syngenesia. (Stamens united by Antheræ, flower compounded.) six orders.

Ex. Dandelion, thistle, sun-flower, tansy, daisy, camomile, blue-bottle, marygold, &c.

Q. Describe the daisy.

A. The daisy, if taken separately, will be found to contain much beauty and variety. The calyx is formed of a double row of spear-shaped leaves, the numerous tabular florets in the centre are yellow, and furnished with both stamens and pistils, while those composing the ray, which are white above, and pink beneath, contain pistils only. The receptacle is naked and conical, and a naked stalk supports a single flower.

CLASS XX. GYNANDRIA. (Stamens situated on the pistils). NINE ORDERS.

Ex. Several well-known field-plants of the orches tribe. They have an oblong withered germ, below the flower, which has no proper calyx, but only sheaths; the corolla consists of five petals, the two innermost of which usually join to form an arch or helmet over the top of the flower In some species the root is composed of a pair of solid bulbs; in others it consists of a set of oblong fleshy substances, tapering towards the ends. The beautiful and scarce flower, called the ladies' slipper, found in its wild state in some unfrequented woods in the north of England, belongs to this class.

CLASS XXII. MONŒCIA. (Stamens and pistils in separate flowers, but upon the same plant.) TEN ORDERS.

Ex. A variety of trees and plants, both native and foreign, belong to this class. Among those of native growth may be enumerated the oak

birch, alder, beech, walnut, sweet chesnut, fir, hazel nut, filbert and mulberry trees, and the numerous kind of sedges. Among the foreign may be reckoned, the bread fruit tree, the cork tree, the cocoa nut tree, the tallow tree, maize, or Indian corn, &c.

Class XXII. Diœcia. (Stamens and pistils distinct, upon different plants.)

EIGHT ORDERS.

Ex. The willow, the parasitical misletoe, the yew tree and hemp.

Class XXIII. Polygamia. (Stamens and pistils variously situated.) THREE ORDERS.

Ex. The plantain tree, a valuable production growing in the West Indies, &c., and is found to be an excellent substitute for bread.

Class XXIV. Cryptogamia. (Flower invisible.)

FOUR ORDERS.

Ex. Mosses, ferns, fungusses, including the mushroom, &c.

CHAPTER VII.

DIRECTIONS FOR FORMING A HORTUS SICCUS, OR HERBARIUM, FOR THE COLLECTION AND PRESERVATION OF PLANTS USED IN BOTANICAL INVESTIGATIONS, &c.

The best method of preserving them is by drying them ; specimens ought to be collected when dry, and carried home in a tin box. Plants may be dried by pressing, in a box of sand, or with a hot smoothing-iron. Each of these has its advantages.

1. If pressure be employed, a botanical press may be procured. The press is made of two smooth boards of hard wood, eighteen inches long, twelve broad, and two thick. Screws must be fixed to each corner with nuts. If a press cannot easily be obtained, books may be employed.

Next, some quires of unsized blossom blotting paper must be provided. The specimens,

when taken out of the tin box, must be carefully spread on a piece of pasteboard, covered with a single sheet of the blossom paper quite dry; then place three or four sheets of the same paper above the plant, to imbibe the moisture as it is pressed out; it is then to be put into the press. As many plants as the press will hold may be piled up in this manner. At first they ought to be pressed gently.

After being pressed for twenty-four hours or so, the plants ought to be examined, that any leaves or petals which have been folded may be spread out, and dry sheets of paper laid over them. They may now be replaced in the press, and a greater degree of pressure applied. The press ought to stand near a fire, or in the sunshine. After remaining two days in this situation, they should be again examined, and dry sheets of paper be laid over them. The pressure then ought to be considerably increased. After remaining three days longer in the press, the plants may be taken out, and such as are sufficiently dry may be put in a dry sheet of writing paper. Those plants which are succu-

lent may require more pressure, and the blossom paper again renewed.

Plants which dry very quickly, ought to be pressed with considerable force when first put into the press; and, if delicate, the blossom paper should be changed every day. When the stem is woody it may be thinned with a knife, and if the flower be thick and globular, as the thistle, one side of it may be cut away; as all that is necessary in a specimen, is to preserve the character of the class, order, genus, and species.

2. Plants may be dried in a box of sand in a more expeditious manner, and this method preserves the colour of some plants better. The specimens, after being pressed for ten or twelve hours, must be laid within a sheet of blossom paper. The box must contain an inch deep of fine dry sand, on which the sheet is to be placed, and then covered with sand an inch thick: another sheet may then be deposited in the same manner, and so on, till the box be full. The box must be placed near a fire for two or three days; then the sand must be carefully removed,

and the plants examined. If not sufficiently dried, they may again be replaced in the same manner for a day or two.

In drying plants with a hot smoothing-iron, they must be placed within several sheets of blotting paper, and ironed till they become sufficiently dry. This method answers best for drying succulent and mucilaginous plants.

When properly dried, the specimens should be placed in sheets of writing paper, and may be slightly fastened by making the top and bottom of the stalk pass through a slip of the paper, cut neatly for the purpose. Then the name of the genus and species should be written down, the place where it was found, nature of the soil, and season of the year. These specimens may be collected into general orders and classes, and titled and preserved in a portfolio or cabinet.

PART III.

CHAPTER I.

VARIOUS PHENOMENA OBSERVABLE IN THE VEGETABLE KINGDOM.

CONSIDERED in various points of view, the vegetable kingdom exhibits innumerable phenomena, which still continue to excite great variety of sentiment and inexhaustible conjecture. Among these, the curious botanist will not fail to observe the locomotive faculty possessed by vegetables; the extreme sensibility of some, and that remarkable phenomenon, in particular, which is called the "sleep of plants!"

That power of changing place, which is called the locomotive faculty, is not peculiar to animals. Examples of different kinds of motion are to be discovered in the vegetable kingdom. When the roots of the tree, for instance, meet with a stone, or any other obstruction to their motion,

in order to avoid it, they change their former direction. They will, moreover, turn from barren to fertile earth, which indicates something analogous to a selection of food, and when confined to a house, they will uniformly bend towards the window, or aperture through which the rays of light are introduced. The sensitive plant *(mimosa)* possesses the faculty of motion in a very eminent degree. On the slightest touch, its leaves suddenly shrink, and together with the branch, bend down towards the earth.

But the *heydasarum gyrans*, or moving plant, from the East Indies, where it is called *chundali borrum*, by the natives, exhibits the most astonishing examples of vegetable motion. Its leaves are incessantly in spontaneous movement, some rising and others falling, and others whirling circularly by twisting their stems. Its motions cease during the night, and when the weather is cold and cloudy. Our wonder is excited by the rapidity and constancy of the movements peculiar to this plant. The frequency, however, of similar motions in other plants, may render it probable that the leaves of all

vegetables move, or are agitated by the rays of the sun, although many of these movements are too slow for our perception.

The American plant, called dionæa muscipula, or Venus' fly trap*, affords another instance of rapid vegetable motion. Its leaves are jointed and furnished with two rows of strong prickles. Their surfaces are covered with a number of minute glands, which secrete a sweet liquor, and allure the approach of flies. When these parts are touched by the legs of a fly, the two lobes of the leaf instantly rise up, the rows of prickles lock themselves fast together, and crush the unwary animal to death. If a straw or pin be introduced between the lobes, the same motions are excited. The author of the 'Botanic Garden,' says, that the sweet viscous liquor we have mentioned, is a curious contrivance of nature, to prevent various insects from plundering the honey, or devouring the seed; and he poetically describes the plant, and this remarkable peculiarity in the following manner:—

* This plant is placed, according to the Linnæan or sexual system of Botany, in the class *Diadelphia*, two brotherhoods, ten males. See p. 114.

The fell Silene and her sisters fair,
Skill'd in destruction, spread the viscous snare.
The harlot band *ten* lofty bravoes screen,
And frowning guard the magic nets unseen.
Haste, glittering nations, tenants of the air,
Oh! steer from hence your viewless course afar!
If with soft words, sweet blushes, nods, and smiles,
The *three* dread syrens* lure you to their toils,
Lured by their art, in vain you point your stings,
In vain the efforts of your whizzing wings!
Go, seek your gilded mates and infant hives,
Nor taste the honey purchased with your lives.

When a seed is sown in a reversed position, the young root turns downwards to enter the earth, and the stem bends upwards into the air. If a young stem be confined to an inclined position, its extremity will soon assume its former perpendicular direction. Twist the branches of any tree in such a manner that the inferior surfaces are turned towards the sky, and in a short time, all these leaves will resume their original position. These motions are performed sooner or later, in proportion to the degree of heat, and the flexibility of the leaves. Many leaves, as those of the mallow, follow the course

* Three females and ten males inhabit each flower.

of the sun. In the morning their superior surfaces are presented to the east; at noon they regard the south; and when the sun sets, they are directed to the west. During the night, or in rainy weather, these leaves are horizontal, and their inferior surfaces are turned towards the earth. The helianthus, or sun flower, also, follows the course of the sun:—

Great Helianthus guides o'er twilight plains
In great solemnity his dervise trains;
Marshall'd in *fives* *, each gaudy band proceeds,
Each gaudy band, a *plumed* † lady leads;
With zealous step he climbs the upland lawn,
And bows in homage to the rising dawn;
Imbibes with eagle-eye the golden ray,
And watches, as it moves, the orb of day.

* The numerous florets, which constitute the disk of this flower, contain in each five males surrounding one female; and the five stamens have their anthers connected at top, whence the name of the class "confederate males."

† The seeds of many plants of this class are furnished with a *plume*, by which admirable mechanism they are disseminated by the winds far from their parent stem, and look like a shittlecock as they fly. Other seeds are disseminated by animals; of these, some attach themselves to the hair or feathers by a gluten, as misletoe; others by hooks, as cleavers, burdock, hound's tongue; and others are swallowed for the sake of the fruit, and voided unin-

What has been denominated "the sleep of plants," affords an instance of another species of vegetable motion. The leaves of many plants fold up during the night; but at the approach of the sun, they expand with new vigour. The common appearances of most vegetables are so changed in the night, that it is difficult to recognize the different kinds, even by the assistance of light.

The modes of folding in the leaves, or of sleeping, are extremely various. But it is worthy of remark, that they all dispose themselves so as to give the best protection to the young stems, flowers, buds, or fruit. The leaves of the tamarind tree contract round the tender fruit, and protect it from the nocturnal cold. The cassia or senna, the glycine, and many of the paplionaceous plants, contract their leaves in a similar manner. The leaves of the chickweed, of the

jured, as the hawthorn, juniper, and some grasses: other seeds again are dispersed by means of an elastic seed-vessel, as oats, geranium, and impatiens; and the seeds of aquatic plants, and of those that grow on the banks of rivers, are carried many miles by the currents into which they fall.

asclepias, atriplex, &c., are disposed in opposite pairs. During the night they rise perpendicularly, and join so close at the top, that they conceal the flowers. The leaves of the sida or althæa theophraste, of the ayenia, and œnothlia, are placed alternately. Though horizontal or even dependent during the day, at the approach of night they rise, embrace the stem, and protect the tender flowers. The leaves of the solanum or night-shade, are horizontal during the day; but in the night, they rise and cover the flowers. The Egyptian vetch erects its leaves during the night, in such a manner, that each pair seems to be one leaf only. The leaves of the white lupine, in the state of sleep, hang down and protect the young buds from being injured by the nocturnal air.

These and similar motions are not peculiar to the leaves of plants. The flowers have also the power of moving. During the night many of them are inclosed in their calices. Some flowers, as those of the German sponge. Geraniums striatum, and common whitlow grass, when

asleep, hang their mouths towards the earth, to prevent the noxious effects of air or dew.

The cause of those movements which constitute the sleep of plants, has been ascribed to the presence or absence of the sun's rays. In some of the examples here given, the motions produced are evidently excited by heat. But plants kept in a hot-house, where an equal degree of heat is preserved both day and night, fail not to contract their leaves, or to sleep, in the same manner as when they are exposed to the open air. This fact evinces, that the sleep of plants is rather owing to a peculiar law, than to a quicker or slower motion of their juices.

In the present imperfect state of human knowledge, it might be presumptuous to exclude plants from every species of sensation; the degrees of which decrease imperceptibly from man to the sea-nettle, gall insects, and what are called the most imperfect animals. Every vegetable, as well as the sensitive plant, shrinks when wounded. But in most of them, the motion is too slow for our perception. When trees grow near a ditch, the roots which pro-

ceed in a direction that would necessarily bring them into the open air, instead of continuing this noxious progress, sink below the level of the ditch, shoot across, and regain the soil on the opposite side. When a root is uncovered without exposing it to much heat, and a wet sponge is placed near it, but in a different direction from that in which the root is proceeding, in a short time the root turns towards the sponge. In this manner the direction of roots may be varied at pleasure.

All plants make the strongest efforts, by inclining, turning, and even twisting their stems and branches, to escape from darkness and shade, and to procure the influence of the sun. Place a wet sponge under the leaves of a tree, they soon bend downward, and endeavour to apply their inferior surfaces to the sponge. If a vessel of water be placed within six inches of a growing cucumber, in twenty-four hours the cucumber alters the direction of its branches, bends either to the right or left, and never stops till it comes in contact with the water. When a pole is placed at a considerable distance from an

unsupported vine, the branches of which are proceeding in a contrary direction from that of the pole, in a short time alters its course, and stops not till it clings round the pole. But facts of this kind, however they may excite our wonder, are far from proving that vegetables live, or that they are endowed with sensation which implies a distinct perception of pleasure and pain.

ANIMAL AND VEGETABLE ANALOGY.

There is unquestionably, a very near approach between plants and animals; and the similarity as well as the difficulty of fixing the precise boundaries by which these two great kingdoms of nature are limited, are direct consequences of the organization of vegetables. It is owing to their organic structure alone, that plants and animals are capable of affording reciprocal nourishment to each other. This organic structure, though greatly diversified in the different species of animals and vegetables, evinces that nature, in the formation of both, has acted upon the same general plan. "May we not presume,

therefore," says an ingenious naturalist*, "that as plants as well as animals are composed of a regular system of organs, that the vegetable part of the creation is not entirely deprived of every quality which we are apt to think peculiar to animated beings? I mean not to insinuate that plants can perceive pleasure or pain. But as many of their motions and affections cannot be explained upon any principle of mechanism, I am inclined to think, that they originate from the power of irritability, which, though it implies not the perception of pleasure and pain, is the principle that regulates all the vital or involuntary motions of animals. To ascertain this point, would require a set of very nice experiments. I shall mention one which might be performed with tolerable ease. It was formerly remarked, that plants kept in a hot house, when the degree of heat is uniform, never fail to sleep during the night. This is direct evidence, that heat alone is not the cause of their vigilance. But they are deprived of light. Let, therefore, a strong artificial light,

* Smellie's Philosophy of Natural History.

without increasing the heat, be thrown upon them. If, notwithstanding this light, the plants are not roused, but continue to sleep as usual, then it may be presumed that their organs, like those of animals, are not only irritable, but require the reparation of some invigorating influence which they have lost while awake, by the agitation of the air and the sun's rays, by the act of growing, or by some other latent cause."

It is remarkable of some plants, that they flower only in the night, and of others that it is then only they emit their fragrance. The cactus grandiflorus, or night blowing cereus, which is a native of Jamaica and Vera Cruz, expands a very exquisitely and beautiful coral, and emits a very fragrant odour for a few hours in the night, and then closes to open no more. The flower is nearly a foot in diameter, the inside of the calyx of a splendid yellow, and the numerous petals of a pure white. It begins to open about seven or eight in the evening, and closes before sun-rise.

The nyctantheus, or Arabian jasmine, is another flower which expands a beautiful coral,

and emits a very delicate perfume during the night, and not in the day, in its native country, whence its name. Botanical philosophers have not yet explained this wonderful property; perhaps the plant sleeps during the day as some animals do, and its odoriferous glands emit their fragrance only during the expansion of the petals; that is, during its waking hours. The geranium tribe has the same property of emitting its fragrance during the night only. The flowers of the cucurbita lagenaria are said to close when the sun shines upon them. In our climate, many flowers, as tragapogon and hibiscus, close their flowers before the hottest part of the day comes on; and the flowers of some species of cuculatus, and silene, viscous campion, are closed all day; but when the sun leaves them, they expand and emit a very agreeable scent. On this account such flowers are called *noctiflori*.

What is in common language called a bulbous root, is by Linnæus called hybernacle, or Winter lodge of the young plant; as these bulbs in every respect resemble buds, except in their being produced under ground, and include the

leaves and flower in miniature, which are to be expanded in the ensuing Spring. By cautiously cutting in the early spring through the concentric coats of a tulip-root, longitudinally from the top to the base, and taking them off successively, the whole flower of the next Summer's tulip is beautifully seen by the naked eye, with its petals, pistil, and stamens; the flowers exist in other bulbs, in the same manner as in the hyacinths, but the individual flowers of these being less, they are not so easily dissected, or so conspicuous to the naked eye. In the seeds of the nymphæa nelumbo, the leaves of the plant are seen so distinctly, that it has been found out by them to what plant the seeds belonged. Ferber (Acad. Vol. vi. No. 120.) says, that Mariotte first observed the future flower and foliage in the bulb of a tulip; and he adds, it is pleasant to see in the buds of the hepatica, and pedicularis hirsuta, yet lying in the earth; and in the gems of daphne mezereon; and at the base of osmunda lunaria, a perfect plant of the future year complete in all its parts.

The retiring of the tulip to its hybernacle, or

Winter lodge, is noticed in the following beautiful manner by the admirable author of the Botanic Garden :—

When o'er the cultured lawns and dreary wastes,
Retiring Autumn flings her howling blasts,
Bends in tumultuous waves the struggling woods,
And showers their leafy honours on the floods,
In withering heaps collects the flowery spoil,
And each chill insect sinks beneath the soil ;
Quick flies fair Tulipa the loud alarms,
And folds her infant closer in her arms ;
In some lone cave, secure pavilion lies,
And waits the courtship of serener skies.
So, six cold moons, the dormouse charmed to rest,
Indulgent sleep! beneath thy elder breast,
In fields of fancy climbs the kernell'd groves,
Or shares the golden harvest with his loves.

There is a curious circumstance relative to the blowing of certain plants also deserving here of some attention ; such, for instance, as in the groundsil, shepherds' purse, daisy, dwarf meadow grass, &c. It should be observed, that though these may, if the Winter prove mild, be found in blossom throughout the year, yet there is a certain month in which they flower more plentifully, and with more certainty than in any other : thus the *shepherds' purse* has the greatest

profusion of bloom in April, the *daisy* in May, the *poa annua* in June, and so on.

What a surprising variety is observable among the flowery tribes! How has the bountiful hand of Providence diversified these nicest pieces of his workmanship; adding the charms of an endless novelty to all their other perfections? A constant uniformity would soon render the entertainment tiresome or insipid; every species, therefore, is formed on a separate plan, and exhibits something entirely new. A family semblance pervades every genus; yet has each species a mode of its own, which is truly original. The most cursory glance perceives an apparent difference, as well as a peculiar delicacy, in the airs and habits, attitude and lineaments of every distinct species.

Some flowers rear their heads with a majestic mien; and overlook, like sovereigns or nobles, the whole parterre. Others seem more moderate in their aims, and advance only to the middle stature; a genius turned for heraldry might term them the *gentry* of the border. While others, free from all aspiring views, creep un-

ambitiously on the ground, and look like the commonalty of the kind. Some are intersected with elegant stripes, or studded with radiant spots. Some affect to be genteelly powdered, or neatly fringed; while others are plain in their aspect, unaffected in their dress, and content to please with a naked simplicity.

Should you ask where and what are the materials which beautify the blooming world? What rich tints, what splendid dyes; what stores of shining crimson, stand by the 'heavenly limner,' when he paints the robe of nature? It is answered, his powerful pencil needs no such costly apparatus. A single principle, under his conducting hand, branches out into an immensity of the most varied and most finished forms. The moisture of the earth, and of the circumambient air, passed through proper strainers, and disposed in a range of pellucid tubes: this performs all the wonders, and produces all the beauties of vegetation. This creeps along the fibres of the long spread moss; and climbs to the very tops of the lofty waving cedar. This, attracted by the root, and circulating through invisible canals; this

bursts into gems, expands itself into leaves, and clothes the forest with all its verdant honours. This one plain and simple cause gives birth to all the charms which deck the youth and maturity of the year. This blushes in the early *hepatica*, and flames in the late advancing poppy. This reddens into blood in the veins of the *mulberry*, and attenuates itself into leafen gold, to create a covering for the *quince*. This breathes in all the fragrant gales of our garden; and weeps odorous gums in the groves of Arabia. So wonderful is our Creator in counsel, and so excellent in his works.

CHAPTER II.

ON THE DECAY AND FALL OF THE LEAVES.

Thick as autumnal leaves that strow the brooks,
In Vallombrosa, where the Etrurian shades
High over-arch'd imbower. MILTON.

Each season of the revolving year produces a variety of picturesque appearances peculiar to

itself. The emotions which affect the mind while it contemplates scenes which every month contributes to diversify, must consequently be of various kinds, all suitable to the season. The vivid beauties of Spring, the glowing skies of Summer, the fading scenes of Autumn, and the dreary aspect of Winter, excite, respectively, vivacity, languor, solemnity, or dejection. Summer, 'refulgent child of the sun,' has retired, with his 'ardent look,' from our northern regions: each gaudy flower disappears, and Winter approaches fast. But the gloom of the falling year is in some measure enlivened, in this month especially, by the variety of colours, some lively and beautiful, which are now assumed by the fading leaves of trees and shrubs.

Those virgin leaves of purest vivid green,
Which charm'd ere yet they trembled on the trees,
Now cheer the sober landscape in decay:
The lime first fading; and the golden birch,
With bark of silver hue; the moss grown oak,
Tenacious of its leaves of russet brown;
Th' ensanguin'd dogwood, and a thousand tints
Which Flora, dress'd in all her pride of bloom,
Could scarcely equal, decorate the groves.

This is a beautiful portrait of the appearance which some trees in particular are observed to exhibit in Autumn. But the inimitable author of the Seasons, with comprehensive eye, extends his view, and describes the diversified aspect of the changing woods, in one wide sweeping landscape, as follows:—

> The fading many coloured woods,
> Shade deep'ning overshade, the country round
> Imbrown; a crowded umbrage, dusk and dun,
> Of every hue, from wan-declining green
> To sooty dark. These now the lonesome Muse,
> Low whispering, lead unto their leaf-strown walk,
> And give the season in its latent view.

From the gradual change and decay of the leaf, we are next invited to contemplate its fall. Here the same author again presents us with a prospect. What he had before described, the general aspect of the woods was obvious, perhaps, to every admirer of nature. But what Poet had ever before described so minute a circumstance, as the effect which the falling leaf has upon the contemplative mind.

> Now the leaf,
> Incessant rustles thro' the mournful grove:
> *Oft startling such as studious walk below,*

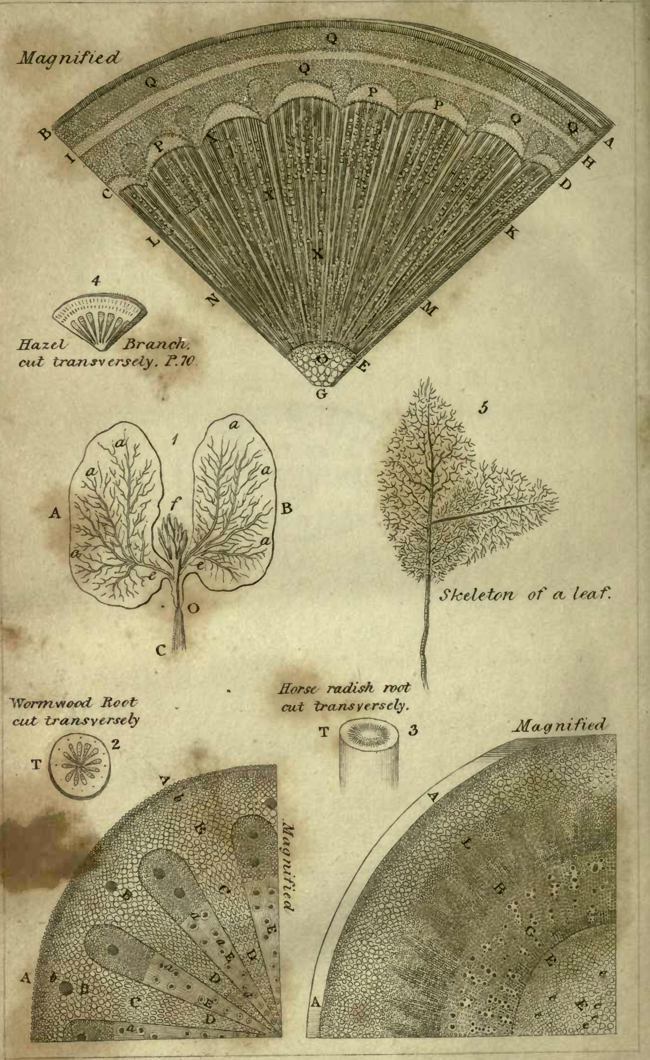
And slowly circles through the waving air.
But should a quicker breeze amid the boughs
Sob, o'er the sky the leafy deluge streams;
Till choak'd, and matted with the dreary shower,
The forest walks, at every rising gale,
Roll wide the withered waste, and whistle bleak.
Fled is the blasted verdure of the fields;
And, shrunk into their beds, the flowery race
Their sunny robes resign. Ev'n what remain'd
Of stronger fruits, falls from the naked tree;
And woods, fields, gardens, orchards, all around,
The desolated prospect thrills the soul.

Such are the appearances and effects which result from the gradual decay and fall of the leaves. But the contemplative philosopher, not satisfied with general appearances and effects, delights to explore with curious eye their latent cause. And when he examines the structure of the leaves of trees, and enquires into their uses, with what a grateful heart he must acknowledge, that the all-wise Creator has not designed them for ornament only, but for the most important service in vegetation.

There are two orders of veins and nerves in leaves, one belonging to each surface; and it has been generally observed, that the lower

lamina, or under side of the leaf, has the ramifications larger, and is capable of admitting a liquid to pass through them, which those of the upper surface will not. These two orders of veins are inosculated * at several places, yet not so closely connected, but that they may be readily separated, after they have been steeped in water a sufficient length of time. Each, it is supposed, are destined for very different purposes. The upper lamina, or coat of veins, is supposed to consist of very minute air-vessels, through which the perspirable matter is secreted, and by which the air is inhaled. This is evident from the clammy substance called honey-dew, which is always found sticking on the upper surface of the leaves. The lower lamina is supposed to be intended for the receiving, preparing, and conveying the moisture, imbibed from the rising vapours of the earth, by which trees and plants are greatly nourished; so that one principal use of leaves is to perform, in some measure, the same office for the support of ve-

* To inosculate, means, *anatomically*, the forming of the mouths of the capillary veins and arteries.


Magnified
4
Hazel Branch.
cut transversely. P.70.
5
1
Skeleton of a leaf.
Horse radish root
cut transversely.
Wormwood Root
cut transversely
2
3
Magnified
Magnified

getable life, as the lungs of animals do for the subsistence of animal life; and for these respective uses the two surfaces are very differently formed. The upper part of the leaf is commonly smooth and lucid; the under one frequently covered with hairs, or a soft down, the better to stop and retain the rising vapours, and to transmit them to the inner vessels. Where the structure of the leaves is different, it has been demonstrated by experience that their functions alter; for in those leaves, whose upper surface is furnished with down or hairs, the upper surface is found to be receiver and conveyer of the moisture, and not the under one, as in most plants. If the surface, therefore, of these be altered, by reversing the branches in which they grow, the plants are stopped in their growth until the footstalks are turned, and the leaves restored to their former position.

Another of the great functions for which the leaves of trees and plants are designed, is that of their footstalks nourishing and preparing the buds of the future shoots, which are always formed at the base of the footstalks. During the

continuance of the leaves in perfect health, these buds increase in magnitude, and in the deciduous trees, are brought to maturity before the foot-stalks separate from the buds in Autumn.

If the leaves be blighted, or their entire surface cut, although the footstalks remain, yet the buds will decay, or not arrive at their proper size, for want of the nourishment which is conveyed to them from the leaves. Whenever, therefore, the trees are divested of their leaves, or these leaves are cut or otherwise impaired, although it happen in either case when the buds are nearly formed; yet if it be before the wood-stalks separate naturally from the branches, the future shoots will be weakened in proportion to the time when this is done. In a word, it is of the utmost consequence not to pull or cut off the leaves of trees or plants, while they retain their verdure, and are in health.

Leaves, moreover, are designed to shade the buds for the future shoots from the sun, which would otherwise exhale and dry up all their moisture. They also shade the young fruit, which is absolutely necessary during the time

of their growth. They throw off by transpiration, what is unnecessary to the growth of the plant; and this, as already remarked, corresponds to the discharge which is made by perspiration in animal bodies. Indeed plants receive and transpire much more in equal time than larger animals. The sun-flower, for instance, has been found, by repeated experiments, to receive and perspire, in twenty-four hours, seventeen times more than a man.

Air evidently passes in at the leaves, and goes through the whole plant, and out again at the roots. If leaves have no air, the whole plant will die. This has been proved by experiments with the air-pump. And plants not only draw through their leaves some part of their nourishment from the air, but the leaves also perform the necessary work of altering the water received in at the roots into the nature and juices of the plant; and hence it isthat the life of the plants depends so immediately on their leaves. The husbandman often suffers for want of this knowledge. A crop of sainfoin is a very valuable thing, and its root being perennial, will yield

him increase many years; but it is often destroyed at first, by suffering it to be indiscreetly fed upon by sheep, which eating up all the leaves, the root remains without the means of receiving a supply of air; and thus the whole plant perishes. This remark has been likewise extended to prove the absurdity of feeding down wheat in the Winter and Spring.

Leaves being thus necessary, nature has, in all perennial plants, provided a reversionary stock of them. The leaves of these plants are always formed in Autumn, though they are not unfolded till the following Spring. They then open and increase gradually, in proportion to the motion of the sap, and the quantity of *pabulum*, or nourishment, it then receives to be circulated. These leaves of evergreens have also a thin compact skin or cover over their surfaces. They are found by experiment to imbibe and perspire but little in the same space of time, when compared with the deciduous trees and shrubs; and it is chiefly owing to this close covering, and to the small proportion of moisture contained in their vessels, that they retain their verdure, and con-

tinue uninjured in the severest frost—a circumstance which is likewise attributable to their oily exterior. Besides these autumnal leaves, there is another set of them formed in the Spring, and expanded about Midsummer. These are of infinite service to many trees, particularly to the mulberry, as they save its life when the Spring leaves have been all eaten up by the silk-worms.

In short, no plant to which nature has allotted leaves, can live without them, but will certainly die if they are pulled off as soon as they appear. The common grass of our meadows and pastures might seem an exception to this general rule; but it is to be considered, that though the sheep eat this down very close, and take off its leaves as soon as they grow, yet when it is thus devoured by cattle, it is only in the leaf, very little of it growing up into the stalk at that time, and therefore less sap is to be purified, and consequently less of the operation allotted to the leaves required. There is, besides, a constant succession of new leaves growing up in the place of the old ones; and many of these being too

short to be bitten off, serve in the place of those which are eaten.

Lastly, the leaf serves, in a singular manner, as already observed, to nourish the eye or germ of the plant, until, growing by degrees to a greater bulk, it presses the vessels of the foot-stalk together, whereby the juice is gradually stopped in the leaf till it cannot any more return through the footstalk; which, by the cessation of the afflux and reflux of the nutritious juice, grows putrid, and the leaf dies and falls off. This is the chief cause of the fall of the leaf in Autumn; but other causes are adduced: one of the most obvious is the coldness of the season; for no sooner are the leaves covered with the first hoar frost, than they are observed to fall in great abundance, and all the trees and plants are stripped of their verdant honours.

The cold, it is said, causes a stagnation of the sap in plants, and prevents its transpiration by the leaves. But this explanation would be insufficient without the solution already given; for the leaves will certainly fall, although it do not freeze during the whole Winter; nor can the

comfortable shelter of green-houses prevent this annual decay and fall. But whatever may be the cause of this vicissitude in the vegetable reign, the decay and fall of the leaves have been favourite themes with poets and philosophers. The first they furnish with beautiful descriptions; the latter with solemn contemplations and pathetic moral sentiment.

There is, indeed, something truly melancholy in the gradual process by which the trees are stripped of all their beauty, and left so many monuments of decay and desolation. Homer, the venerable father of poetry, has deduced from this quick succession of springing and falling leaves, a very apposite comparison for the transitory generations of men :—

> Like leaves on trees the race of man is found,
> Now green in youth, now withering on the ground,
> Another race the following Spring supplies,
> They fall successive, and successive rise ;
> So generations in their course decay,
> So flourish these, when those are past away.
>
> POPE.

CHAP. III.

DEWS.

Celestial dews, descending o'er the ground,
Perfume the mount, and breathe ambrosia round.

POPE.

There is not a phenomenon in nature more common, or more beautiful, than that of the dew. Like the fall of the leaf, the poets have seized upon it with avidity, to decorate their favourite themes, and particularly their descriptions and personification of the morning. It is here only as an instrument in the process of vegetation that we shall consider it; leaving the pleasing ideas of the 'orient pearl' to the fairy region of the poet's fancy, to discuss the subject in a more substantial and philosophic point of view.

Dew is generally ranked by naturalists among the aqueous meteors, those bodies that exist in the atmosphere in a flux and transitory state. It consists of a dense, moist vapour, found upon the earth in Spring and Summer mornings, in

the form of a misling rain; and is chiefly collected while the sun is below the horizon.

It has been disputed whether the dew is formed from the vapours *ascending* from the earth during the night-time, or from the descent of such as have been already raised through the day. The most remarkable experiments adduced in favour of the first hypothesis, are those of M. Dufay, of the Royal Academy of Sciences, at Paris. He supposed, that if the dew *ascended*, it must wet a body placed low down sooner than one placed in a higher situation; and if a number of bodies were placed in this manner, the lowermost would be wetted first; and the rest in like manner, gradually up to the top.

Ex. To determine this, M. Dufay placed two ladders against one another, meeting at their tops, spreading wide asunder at the bottom, and so tall as to reach thirty-two feet high. To the several steps of these he fastened large squares of glass like the panes of windows, placing them in such a manner, that they should not overshade one another. On trial, the result was such as expected by M. Dufay. The lower surface of the lowest piece of glass was first wetted,

then the upper, then the lower surface of the pane next above it, and so on, till all the pieces were wetted to the top. Hence it appeared plain to him, that the dew consisted of the vapours ascending from the earth during the night time; which being condensed by the coldness of the atmosphere, are prevented from being dissipated as in the day-time by the sun's heat.

A similar experiment was afterwards tried with pieces of cloth instead of panes of glass, and the result was quite conformable to his expectations. The next morning all the pieces of cloth were weighed, in order to ascertain what quantity of water each piece had imbibed, when those that had been placed lowermost were considerably heavier than such as had been placed at the top; although M. Dufay confessed that this experiment did not succeed so perfectly as the former.

M. Muschenbrock, who embraced the contrary opinion, thought he had invalidated all M. Dufay's proofs, by repeating his experiments with the same success, on a plane covered with sheet-lead. But to this M. Dufay replied, that there was no occasion to suppose the vapour to

rise through the lead, nor from that very spot; but that as it arose from the adjoining open ground, the continual fluctuation of the air could not but spread it abroad, and carry it thither in its ascent.

But although M. Muschenbrock's experiment is not sufficient to overthrow those of M. Dufay, it must still remain dubious whether the dew rises or falls. One thing which seems to favour the hypothesis of its *descent* is, that in cloudy weather there is little or no dew to be observed. From this M. De Luc brings an argument in favour of the last hypothesis, the descent of the dew—and he accounts for it in the following manner:—

When there are no clouds in the air, the heat of the inferior air and of that which rises from the earth is dissipated into the inferior regions; and then the vapours, which are dispersed throughout the air, condense and fall down in dew. But when the clouds continue, they separate the inferior from the superior part of the atmosphere, and thus prevent the dissipation of the heat, by which means the vapours remain

suspended. When the sky grows cloudy, some hours after sun-set, although the heat has been sensibly diminished, it is again increased; because, continuing to rise out of the earth, it is accumulated in the inferior air. But neither can this be deemed a positive proof of the descent of the dew; since we may as well suppose the heat of the atmosphere to be great enough to dissipate it on its ascent as to keep it suspended after its ascent after the heat of the day.

On the other hand, the dew being found in greater quantities on bodies placed low down, than on such as are high up, is no proof of the *ascent* of the dew, for the same thing is observed of rain. A body placed low down receives more rain than one placed in an elevated situation; and yet the rain certainly descends from the atmosphere. The reason why the dew appears first on the lower parts of bodies may be, that, in the evening, the lower part of the atmosphere is first cooled, and consequently most disposed to part with its vapour. It is also certain, that part of the water contained in the air may be condensed at any time on the sides of a glass,

by means of cold, so as to run down its sides in small drops like dew. It seems, therefore, that this subject is not sufficiently determined by such experiments as have hitherto been made; nor indeed does it appear easy to make such experiments, as shall be perfectly *decisive* on the subject.

But however this may be determined, it is certain that several substances, exposed to the same dew, receive and change themselves with it in a very different manner; some more, some less, and others not at all. The drops seem to make a sort of choice of what bodies they shall affix themselves to; glass and crystals are those to which they adhere themselves in the most ready manner, and in the largest quantity; but metals of every kind do not receive them at all, nor do the drops ever adhere to them. The reason of this probably is, because metals promote evaporation more than glassdoes. Thus, if a piece of metal and a piece of glass are both made equally moist, the former will be found to dry in much less time than the latter. Hence it would seem, that there is between metals and

water some kind of repulsion, which may be sufficient to keep off the very small quantity that falls on the dew; for whatever tends to make water evaporate, after it is actually in contact with any substance, tends also to keep the water from ever coming into contact with it.

Of the dew of plants, it has been observed, that it is probably only the moisture that continually exhales through the orifices of their vessels, and not a vapour collected by their leaves; this dew being exhaled by each plant, according to the peculiar structure of its vessels, and the situation of their orifices. Indeed, it is certain that plants, which have been shut up in vessels, and covered by glasses, have collected a greater quantity of dew, than those that stood in the open air; and farther, the drops are gathered in those parts where the orifices of the vessels are manifestly open, and not all over the leaves, nor in the upper and lower leaves only (which would be the case if they rose from ambient vapour), but in all the leaves without distinction. The oil, or honey dew, which is sometimes exhaled in Summer, by trees and herbs, and which

has been found to settle on the oak, ash, &c. is of this kind.

Between sixty and seventy years ago, Mr. Thomas Melville, a very ingenious writer in the "Essays, Physical and Literary, by the Edinburgh Society," published some observations, "on the silver-like appearance of drops of water on the leaves of colewort."—"It is common," says he, to "admire the volubility and lustre of drops of rain that lie on the leaves of colewort and some other vegetables; but no philosopher, as far as I know, has put himself to the trouble of explaining this curious phenomenon. Upon inspecting them narrowly, I find that the lustre of the drop arises from a copious reflection of light from the flattened part of its surface contiguous to the plant. I observe further, that when the drop rolls along a part which has been wetted, it immediately loses all its lustre; the green plant being then seen clearly through it, whereas in the other case, it is hardly to be discerned.

"From these two observations laid together, we may observe, that the drop does not really

touch the plant when it has the mercurial appearance, but hangs in the air at some distance from it, by the force of a repulsive power; for there could not be any copious reflection of white light from its under surface, unless there were a real interval between it and the surface of the plant.

"If that surface were perfectly smooth, the under surface of the drop would be so likewise; and would therefore shew an image of the illuminating body by reflection, like a piece of polished silver; but as it is considerably rough and unequal, the under surface likewise becomes rough; and so by reflecting the light copiously in different directions, assumes the resplendent white colour of unpolished silver.

"After it is proved by optical argument, that the drop is really not in contact with the plant which supports it, we may easily conceive whence its wonderful volubility arises, and why it leaves no track of moisture where it rests.

Mr. Melville's explanation will enable us to account for that common phenomenon, the suspension of the drops of dew on the very summits of the blades of grass, &c. and their assum-

ing that pearly or resplendent white colour, which he observed in the drops on the leaves of colewort. This ingenious explanation, at the same time, shews the extensive utility of optical principles, in leading to the knowledge of things which would be otherwise inaccessible.

Our limits will not allow us to enlarge on the great benefit of the dews in the refreshment of the earth, and the nourishment of plants. "How sensibly," observes a pious author, "has this dew refreshed the vegetable kingdoms! The fervent heat of yesterday's sun had almost parched the face, and exhausted the sweets of nature. But what a sovereign restorative are these cooling distillations of the night! How they gladden and invigorate the languishing herbs! sprinkled with these reviving drops, their verdure deepens, their bloom is new-flushed; their fragrance faint, or intermitted, becomes potent and copious."

In hot countries, and in places where it rains but seldom, the dew of the night supplies, in some measure, the want of rain. In the sacred scriptures, therefore, it is reoresented as a great

blessing: "Blessed of the Lord," says Moses, speaking of Joseph, "be his land for the precious things of heaven, *for the dew* *, &c. And the want of it is represented as a curse: "Ye mountains of Gilboa," said David, "*let there be no dew* †." The favour of the Divine Being is compared to the dew: "I will be," says the Lord, "as the dew unto Israel: he shall grow as the lily, and cast forth his shoots in Lebanon ‡." Heavenly doctrine, or the word of God, is likewise compared to the dew: "my doctrine," says Moses, "shall drop as the rain, my speech shall *distil as the dew;* as the small rain upon the tender herb, and as the showers on the grass; that is, my doctrine shall have the same effect upon your hearts as the dew has upon the earth: it shall render them soft, pliable, and fruitful." But the admirable allusions to the dew, in holy writ, are too numerous to be quoted.

Our divine bard, Milton, has not forgotten to

* Deut. xxxiii. 13.

† 1 Sam. i. 21.

‡ Hos. xiv. 5. See also Zacch. vii. 12.

give them all their importance: he introduces them into his descriptions with a peculiar felicity:—

Now morn her rosy steps in th' eastern clime,
Advancing, sow'd the earth with orient pearl.

And speaking of the prodigious host of Satan, he has introduced the dews into the following most beautiful simile:—

——————————— an host,
Innumerable as the stars of night,
Or stars of morning, dew-drops, which the sun
Impearls on every leaf and every flower.

Innumerable as the stars is an old simile; but this of the stars of morning, dew-drops, seems as new as beautiful. And the sun empearls them; that is, turns them by his reflected beams to seeming pearls, as the morn was said above to sow the earth with orient pearl.

A favourite comparison with our English poets is that of tears to dew, or the dew to tears, Thus Shakspeare:—

And that some dew, which sometime on the buds
Was wont to swell like round and orient pearls,
Stood now within the pretty flowret's eyes,
Like tears, that did their own disgrace bewail.

In Samson Agonistes, where Dalilah comes to visit her eyeless husband, she is afraid to approach; and Milton has made her silence most beautifully expressive: the chorus tells Sampson,

Yet on she moves, now stands, and eyes she fixed,
About t' have spoke, but now with head declined,
Like a fair flower surcharged with dew, she weeps,
And words addressed, seem into tears dissolv'd,
Wetting the borders of her silken veil.

In Virgil, the *ros in tenera pecori gratissimus herba.* The dew on the tender grass, grateful to the cattle, is rendered by Dryden the *pearly drops of morning dews,* and by Dr. Warton *the morning's earliest tears.* Nor has Pope neglected them in his "Elegy to the Memory of an unfortunate Lady."

Yet shall thy grave with rising flowers be drest,
And the green turf lie lightly on thy breast:
There shall *the morn her earliest tears bestow,*
There the first roses of the year shall blow.

And most of our readers may recollect the celebrated couplet of Lord Chesterfield, in his "Advice to a Lady in Autumn."

The dews of the evening most carefully shun;
Those *tears of the sky,* for the loss of the sun.

Gray, in his "Elegy in a Country Churchyard," exhibits a fine picture of a melancholy man :—

> Haply some hoary-headed sage may say,
> "Oft have we seen him at the peep of dawn,
> "Brushing with hasty steps the dews away,
> "To meet the sun upon the upland lawn."

In a word, the dew, these "transparent beauties of the morn," not only furnish us with poetic images and philosophic knowledge, but with very powerful motives also for a life of piety, benevolence, and virtue. Their great utility to the vegetable kingdom in particular, should lead us to the increasing adoration of that gracious being, who created nothing which has existence, merely for an object of idle speculation. When we consider, moreover, how silently and insensibly "the light-footed dews," fulfil the gracious purposes of our common benefactor; incessantly dispensing nutriment to vegetable life, and refreshment to animated being; how persuasively should this instruct the rich and opulent, to let their secret bounty, unostentatious as the dew of heaven, descend continu-

ally to revive the drooping hearts of modest and unassuming worth. For what are the high and mighty of the earth, without that bliss-diffusing spirit of humanity, whose exertions, while they tend every day to dignify its noble possessor, prepare and mature him for immortality? What, I repeat it, are illustrious titles and unbounded affluence, without this divine spirit, but the momentary radiance of the same morning dews which glitter awhile, and then vanish for ever?

CHAPTER IV.

CHEMICAL PHENOMENA OF GERMINATION AND VEGETATION.

GERMINATION.

Germination is the process by which a new plant originates from seed.

A seed consists essentially of two parts, the *germ* of the future plant, endued with a principle of vitality, and the *cotyledons* or *seed-lobes*

both of which are enveloped in a common covering of cuticle. See p. 63, &c.

In the germ two parts, the *radicle* and *plumula,* may be distinguished, the former of which is destined to descend into the earth and constitute the root, the latter to rise into the air and form the stem of the plant. The office of the seed-lobes is to afford nourishment to the young plant until its organization be so far advanced, that it may draw materials for its growth from extraneous sources. For this reason seeds are composed of highly nutritious ingredients. The chief constituents of most of them is starch, in addition to which, they frequently contain gluten, gum, vegetable albumen, or curd, and sugar.

The conditions necessary to germination are three-fold; namely, moisture, a certain temperature, and the presence of oxygen gas. The necessity of moisture to this process has been proved by extensive observation. It is well known the concurrence of other conditions cannot enable seeds to germinate, provided they are quite dry. A certain degree of warmth is

not less essential than moisture. Germination cannot take place at thirty-two degrees of Fahrenheit; and a strong heat, such as that of boiling water, prevents it altogether, by depriving the germ of the vital principle. The most favourable temperature for germination ranges from sixty to eighty degrees, the precise degree varying with the nature of the plant, a circumstance that accounts for the difference in the season of the year at which different seeds begin to germinate.

That the pressure of air is necessary to germination was demonstrated by several philosophers, such as Ray, Boyle, Muschenbrock, and Boerhaave, before the chemical nature of the atmosphere was discovered; and Scheele, soon after the discovery of oxygen*, proved that beans do not germinate without exposure to that gas. The same fact was afterwards demonstrated by Achard, with regard to seeds in general, and his

* Oxygen gas was discovered by Priestley, in 1774, and by Scheele, a year or two after, without previous knowledge of Priestley's discovery. Several appellations have been given to it. Priestley named it *Dephlogisticated air;* by Scheele it was called *Empyreal air*, and by Condorcet,

experiments have been fully confirmed by subsequent observers. It has even been shown by Humboldt, that a dilute solution of chlorine *, owing to the tendency of that gas to decompose water, and set oxygen at liberty, promotes the germination of seeds. These circumstances account for the fact that seeds, when buried deep in the earth, are unable to germinate.

It is remarkable that the influence of light, which is so favourable to all the subsequent stages of vegetation, is injurious to the process of germination. Ingenhousz and Senebier, have proved that a seed germinates more rapidly in the shade than in the light, and in diffused

Vital air. The name it now bears, derived from the Greek words, οξυς *acid*, and γεννάω, "*I generate*," was proposed by Lavoisier, from the supposition that it was the sole cause of acidity. *See First Lines of Chemistry.*

* Chlorine was discovered in 1770, by Scheele, while investigating the nature of manganese, and he described it under the name of *Dephlogisticated marine acid*. The French chemists called it *oxygenized muriatic acid*, a term which was afterwards contracted to oxymuriatic acid, from an opinion proposed by Berthollet, that it is a compound of muriatic acid and oxygen : though in fact it possesses no acid properties.

day-light quicker than when exposed to the direct solar rays.

From the preceding remarks it is apparent, when a seed is placed an inch or two under the surface of the ground in Spring, and is loosely covered with earth, it is in a state every way conducive to germination. The ground is warmed by absorbing the solar rays, and is moistened by occasional showers; the earth at the time protects the seed from light, but by its porosity gives free access to the air.

The operation of malting barley, in which the grain is made to germinate by exposure to warmth, air, and humidity, affords the best means of studying the phenomena of germination. In this process, water is absorbed, the cotyledon swells and ruptures its cuticle, and soon after the radicle and plumula are protruded. On examining the grain at this period, it is found to have undergone an essential change in the proportion of its ingredients, as appears from the result of Proust's comparative analysis of matter and unmalted barley. (*An. de ch. et de Philos.* tome v.)

	In 100 parts barley.	In 100 parts malt.
Resin	1	1
Gum	4	15
Sugar	5	15
Gluten	3	1
Starch	32	56
Hordein	55	12

Hence it is apparent that in germinations the hordein is converted into starch, gum, and sugar; so that from an insoluble material, which could not in that state be applied to the uses of the young plant, two soluble and highly nutritive principles result, which, by being dissolved in water, are readily absorbed by the radicle.

CHEMICAL CHANGES IN GERMINATION.

The chemical changes which occur during the process of germination, have been ably investigated by Saussure. The leading facts which he determined are the following:—that oxygen is consumed, that carbonic acid is evolved; and that the volume of the latter is precisely equal

to that of the former. Now since carbonic acid gas contains its own volume of oxygen, it follows that this gas must be united exclusively with carbon. It is likewise obvious that the grain must weigh less after than before germination, provided it is brought to the same state of dryness in both instances. Saussure, indeed, found that the loss is greater than can be accounted for by the carbon of the carbonic acid which is evolved, and hence he concluded that a portion of water, generated at the expense of the grain itself, is dissipated in drying. According to Proust, the diminution in weight is about one-third; but Dr. Thomson affirms that fifty processes, conducted on a scale under his inspection, the average loss did not exceed one-fifth.

CHAPTER V.

THE GROWTH OF PLANTS.

While a plant differs from an animal in exhibiting no signs of perception or voluntary motion, and in possessing no stomach to serve as a receptacle for its food, there exists between them a close analogy, both of parts and functions, which, though not discernable at first, becomes striking on a close inspection. The stem and branches are on a frame-work or skeleton, for the support and protection of the parts necessary to the life of the individual. The root serves the purpose of a stomach by imbibing nutritious juices from the soil, and thus supplying the plant with materials for its growth. (See p. 132.)

CIRCULATION OF THE SAP, &c.

The sap is circulating, composed of water, holding in solution saline, extractive, mucilagi-

nous, saccharine, and other soluble substances; rises upwards through the wood in a distinct system of tubes called the common vessels, which correspond in their office to the lacteals and pulmonary arteries of animals, and are distributed in minute ramifications over the surface of the leaves. In its passage through this organ, which may be termed the lungs of a plant, the sap is fully exposed to the agency of light and air, experiences a change by which it is more completely adapted to the wants of the vegetable economy, and then descends through the inner layer of the bark in another system of tubes, called the *proper vessels,* yielding in its course all the juices and principles peculiar to the plant.

The chemical changes which take place during the circulation of the sap are in general of such a complicated nature, and so much under the controul of the vital principle, as to elude the sagacity of the chemists. One part of the subject, however, namely, the reciprocal agency of the atmosphere, and growing vegetables on each other, fall within the reach of chemica

enquiry, and has accordingly been investigated by several philosophers.

RESPIRATION OF PLANTS.

For the leading facts, relative to which is called the *respiration* of plants, or the chemical changes which the leaves of growing vegetables produce on the atmosphere, we are indebted to Priestley and Ingenhousz, the former of whom discovered that plants absorb carbonic acid from the air under certain circumstances, and emit oxygen in return; and the latter ascertained that this change occurs only during exposure to the direct rays of the sun. When the roots of a healthy plant, supported with proper nourishment, are exposed to the direct solar beams, in a given quantity of atmospheric air, the carbonic acid, after a certain interval, is removed, and an equal volume of oxygen is substituted for it. If a fresh portion of carbonic acid be supplied, the same result will ensue. The like manner, Sennebier and Woodhouse observed, that when the leaves of a plant are immersed in water, and exposed to the rays of the sun, oxygen gas is

disengaged. That the evolution of oxygen in this experiment is accompanied with a proportional absorption of carbonic acid by boiling, in which case no oxygen is procured. Such are the changes induced by plants when exposed to the sun, but in the dark an opposite effect ensues. Under these circumstances, carbonic acid is not absorbed, nor is oxygen evolved; on the contrary, oxygen disappears, and carbonic acid is disengaged. In the dark, therefore, vegetables deteriorate rather than purify the air, producing the same effect as the respiration of animals.

⁎ From several of the preceding facts, it is supposed that the oxygen emitted by plants, while under the influence of light, is derived from the carbonic acid which they absorb, and that the carbon of that gas is applied to the purposes of nutrition. Consistently with this view it has been observed that plants do not thrive when kept in an atmosphere of pure oxygen; and it was found by Dr. Percival and Dr. Henry, that the presence of a little carbonic acid is favourable to their growth. Saussure, who examined this subject minutely, ascertained

that plants grow better in an atmosphere which contains about one-twelfth of carbonic acid, than in common air, provided they are exposed to sunshine. But if that gas be present in a greater proportion, its influence is prejudicial; in an atmosphere consisting of one half its volume of carbonic acid, the plants perished in seven days, and they did not vegetate at all when that gas was in proportion of two-thirds. In the shade, the presence of carbonic acid is always detrimental. Saussure also observed that the presence of oxygen is necessary, in order that a plant should derive benefit from admixture with carbonic acid. He is also of opinion these plants derive a large quantity of their carbon from the carbonic acid of the atmosphere—an opinion which receives great weight from the two following comparative experiments; namely—on causing a plant to vegetate in pure water, supplied with common air, and exposed to light, the carbon of the plant increased in quantity; but when supplied with common air, in a dark situation, it even lost a

portion of the carbon which it had previously possessed.

Light is necessary to the colour of plants. The experiments of Sennebier and Mr. Gough have shewn that the green colour of the leaves is not developed, except when they are in a situation to absorb oxygen, and give out carbonic acid. Though the experiments of different philosophers agree as to the influence of vegetables on the air in sunshine and during the night, considerable uncertainty prevails both as to the phenomena occasioned by diffused daylight, and concerning the total effect produced by plants on the constitution of the atmosphere. Priestley found that air, vitiated by combustion, or the respiration of animals, and left in contact for several days and nights with a sprig of mint, was gradually restored to its original purity; and hence he inferred that the oxygen gas consumed during these and various other processes, is restored to the mass of the atmosphere by the agency of growing vegetables; and the researches of Ingenhousz and Saussure confirmed this opinion; as they were led to

adopt the opinion, that the quantity of oxygen gas evolved from plants by day, exceeds that of carbonic acid emitted during the night. On the contrary, the conclusions of Mr. Ellis are precisely the reverse*; who inferred, the result of a series of well contrived experiments, that growing plants give out oxygen only in direct sunshine, while at all other times they absorb it when exposed to the ordinary vicissitudes of sunshine and shade, light and darkness; they form more carbonic acid in the period of a day and night, than they destroy; and consequently, that the general effect of vegetation on the atmosphere is the same as that produced by animals. (See pp. 53 and 54.)

This question has been ably discussed by Sir H. Davy, who is of opinion, that the experiments of Mr. Ellis cannot be regarded as decisive, having been conducted under circumstances unfavourable to accuracy of result.

* See Ellis's Researches and Farther Inquiries on Vegetation, &c.

CHAPTER VI.

FOOD OF PLANTS.

The chief source, we have already observed, (See p. 70.) from which plants derive the materials for their growth, is the soil. Various as may be the composition of the soil, it consists essentially of two parts, so far as its solid constituents are concerned. The first is a certain quantity of earthy matters, such as sebaceous earth, clay, lime, and sometimes magnesia; the other is formed from the remains of animal and vegetable substances, which, when mixed with the former, constitute common mould. A mixture of this kind moistened by rain, affords the proper nourishment of plants. The water filtering through the mould dissolves the soluble salts with which it comes in contact, together with the gaseous extractive, and other matters which are formed during the decomposition of the animal and vegetable remains. In this state it

is readily absorbed by the roots, and conveyed as sap to the leaves, where it undergoes a process of assimilation. But though this be the natural process by which plants obtain the greater part of their nourishment, and without which they do not arrive at perfect maturity, they may live, grow, and even increase in weight, when wholly deprived of nutrition from this source. Thus in the experiment of Saussure, already described, sprigs of peppermint were found to vegetate in distilled water; and it is well known that many plants grow when merely suspended in the air. In the hot-houses of the botanical garden of Edinburgh, for example, there are two plants, species of the fig-tree, the *ficus australis* and *ficus elastica,* the latter of which, as Dr. Graham asserts, has been suspended for more than two, and the former for eight years, during which time they have continued to send out shoots and leaves.

Before the influence of atmospheric air on vegetation was appreciated, the increase of carbonaceous matter, which occurs in some of these instances was supposed to be derived from water, an opinion naturally suggested by the

important offices performed by this fluid in the vegetable economy.

Without water, plants speedily wither and die. It gives the soft parts that degree of succulence necessary for the due performance of their functions;—it affects two elements, oxygen and hydrogen, which, either as water, or under some other form, are contained in all vegetable products; and, lastly, the roots absorb from the soil those substances only, which are dissolved or suspended in water. So carefully indeed, has nature provided against the chance of deficient moisture, that the leaves are endowed with a property both of absorbing aqueous vapour directly from the atmosphere, and of lowering their temperature during the night by radiation, so as to cause a deposition of dew upon their surface, in consequence of which they frequently, during the dryest seasons and in the warmest climates, continue to convey this fluid to the plant, when it can no longer be obtained in sufficient quantity from the soil. Necessary, however, as this fluid may be to vegetable life, it cannot yield to plants a principle which it does not possess. The car-

bonaceous matter which accumulates in plants, under the circumstances above-mentioned, may, with every appearance of justice, be referred to the atmosphere, since it is known that carbonic acid exists there, and that growing vegetables have the property of taking carbon from that gas.

INCINERATION OF PLANTS.

When plants are incinerated or reduced to ashes, these ashes are found to contain saline and earthy matters, the elements of which, if not the compounds themselves, are supposed to be derived from the soil. Such at least is the view deducible from the investigation of Saussure, and which might have been anticipated by reasoning on chemical principles. The experiments of M. Schrader, however, lead to a different conclusion. He sowed several kinds of grain, such as barley, wheat, rye, and oats, in pure flower of sulphur, and supplied the shoots as they grew, with nothing but air, light, and distilled water. On reducing the plants to ashes thus treated, they yielded a greater quantity of saline and earthy matters than were originally present in the seeds. These results, supposing them accurate, may be accounted for in two ways.

In the first place, it may be supposed that the foreign matters were introduced accidentally from extraneous sources, as by fine particles of dust floating in the atmosphere; or, secondly, it may be conceived, that they were derived from the sulphur, air, and water, with which the plants were supplied. If the latter opinon be adopted, it must be inferred either that the vital principles which certainly controls chemical affinity in a surprising manner, and directs this power in the production of new compounds, from elementary bodies, may likewise convert one element into another; or that some of the substances, supposed by chemists to be simple, such as oxygen and hydrogen, are compounds, not of two, but of a variety of different principles. As these conjectures are without foundation, and are utterly at variance with the facts and principles of the science, we do not hesitate in adopting the more probable opinion, that the experiments of Schrader were influenced by some source of error which escaped detection.—See *Turner's Elements of Chemistry, &c.* p. 613.

FINIS.

Forsyth
First lines of botany

F6

Jun 25 1912	Bynum	JUN 26 1912
JUL 29 1912	Bannister	JUL 31 1912
SEP 10 1913	Kennett	SEP 20 1913
APR 8 1919	Williamson	
MAR 9 1925	Sager	FEB 24 1925
SEP 20 1935	Nelson	SEP 19 1935

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